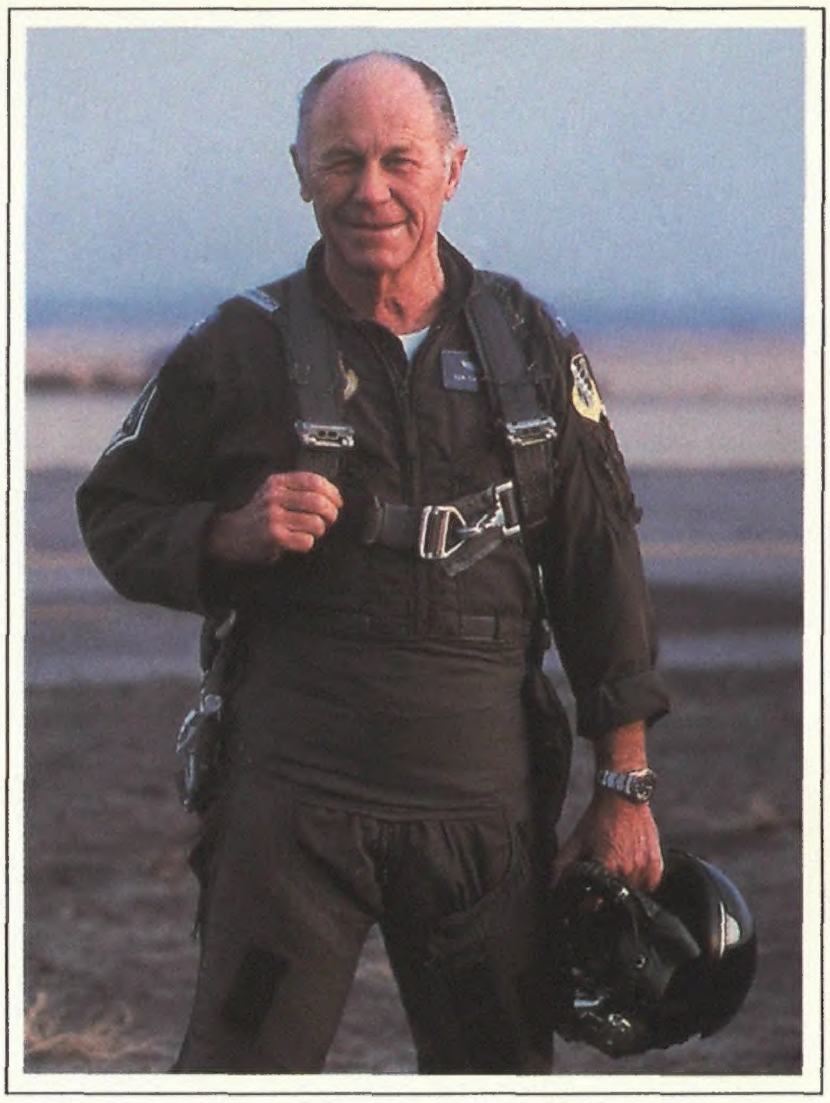
June/July 1987

AIR & SPACE

Smithsonian

Tactics analyst Christine Fox figured in the film *Top Gun*



To the first man to break the sound barrier, Rolex is essential equipment.

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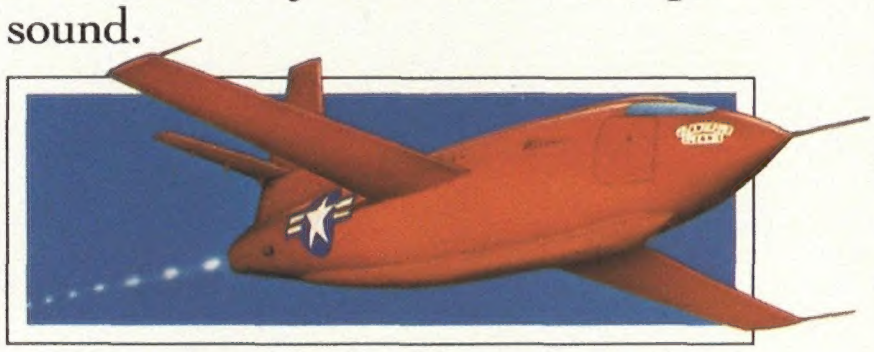

The Bell X-1, first to fly faster than the speed of sound.

An uncommon mix of drives and talents contributes to the general's achievements: the grit to press to the outer limits of speed, an insatiable lust for flight, extraordinary eyesight and reflexes, and an instinct for choosing the right equipment. Like the Rolex Oyster that has served him through 4 decades, even on punishing supersonic flights.

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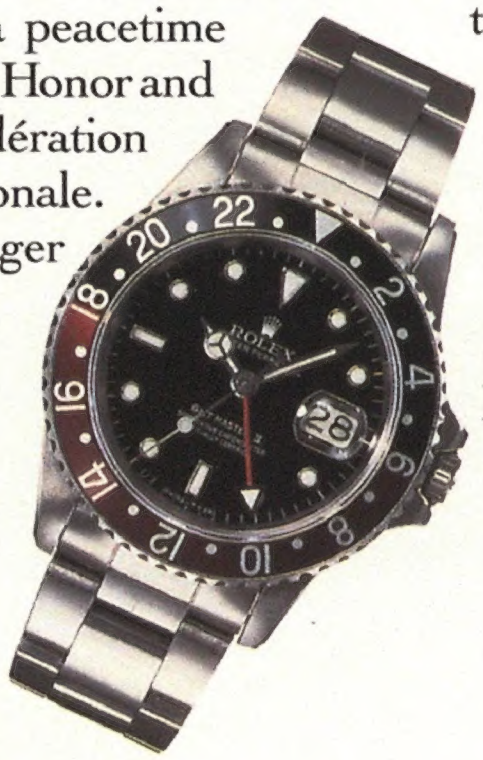
Honors abound for such a man. His many awards include a peacetime Congressional Medal of Honor and the gold medal of the Fédération Aéronautique Internationale.

Today, General Yeager may well be America's most celebrated pilot. His exploits were featured in the Academy Award-winning film *The Right Stuff.* And his autobiography, *Yeager,* became a best-seller.



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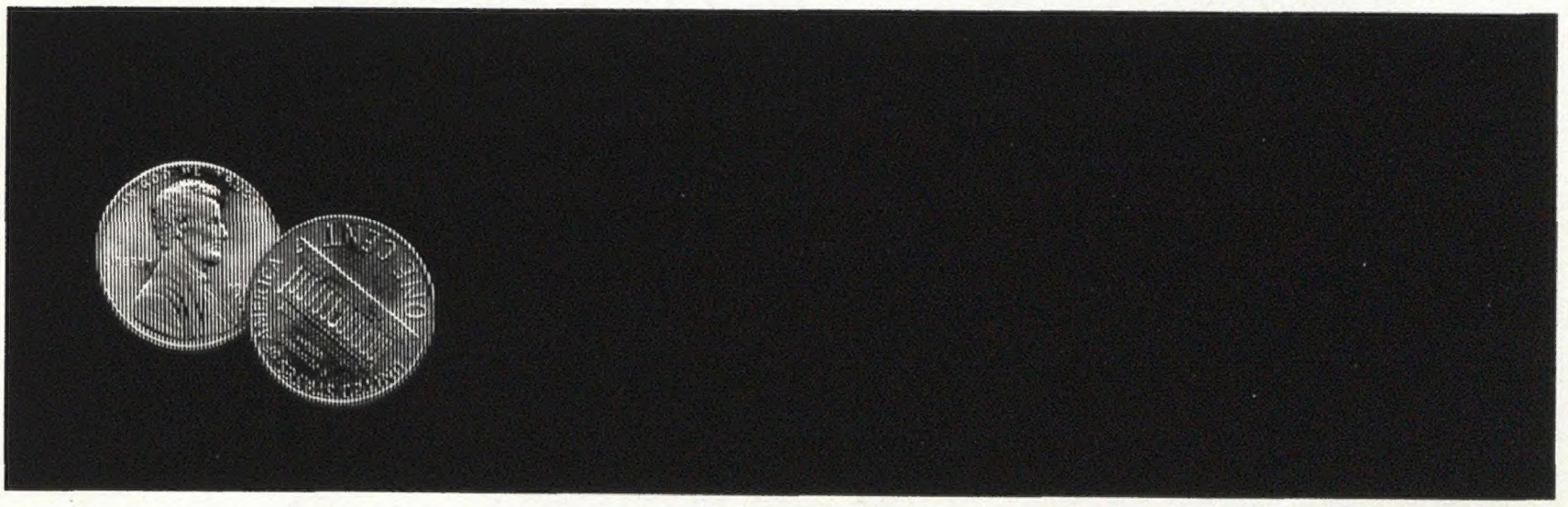

The Space Station's potential for improving life on our planet is boundless. Yet the cost of building and maintaining it comes to roughly two cents a day for every American. Your support for the NASA Space Station will make a difference. So get your two cents' worth in. Say yes to America's manned space station program.

MCDONNELL DOUGLAS

June/July 1987 Volume 2, Number 2

AIR&SPACE
Smithsonian

Contents

Cover: *Christine Fox, wreathed in naval aviators, is at the center of Chad Slattery's camera.*

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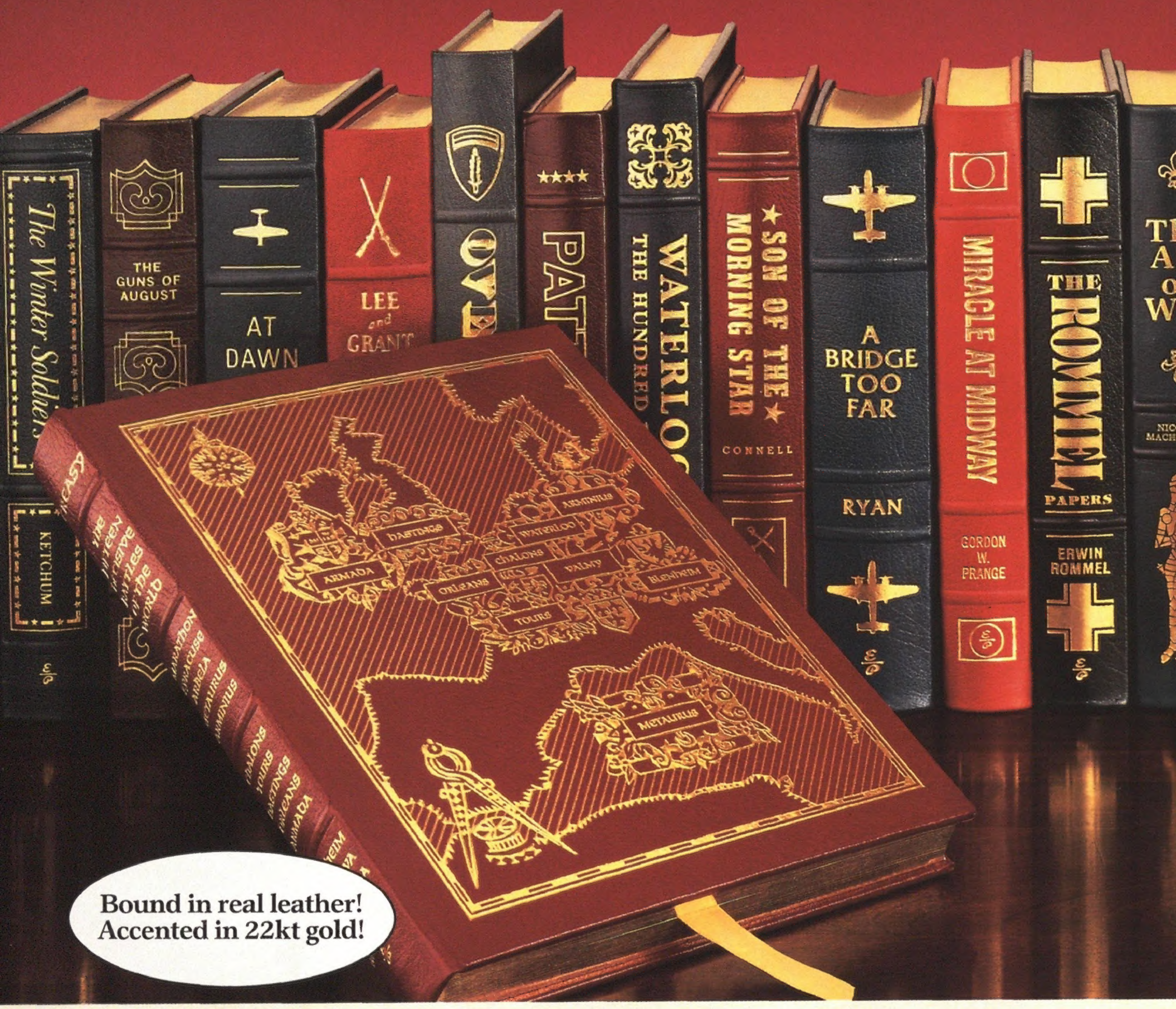

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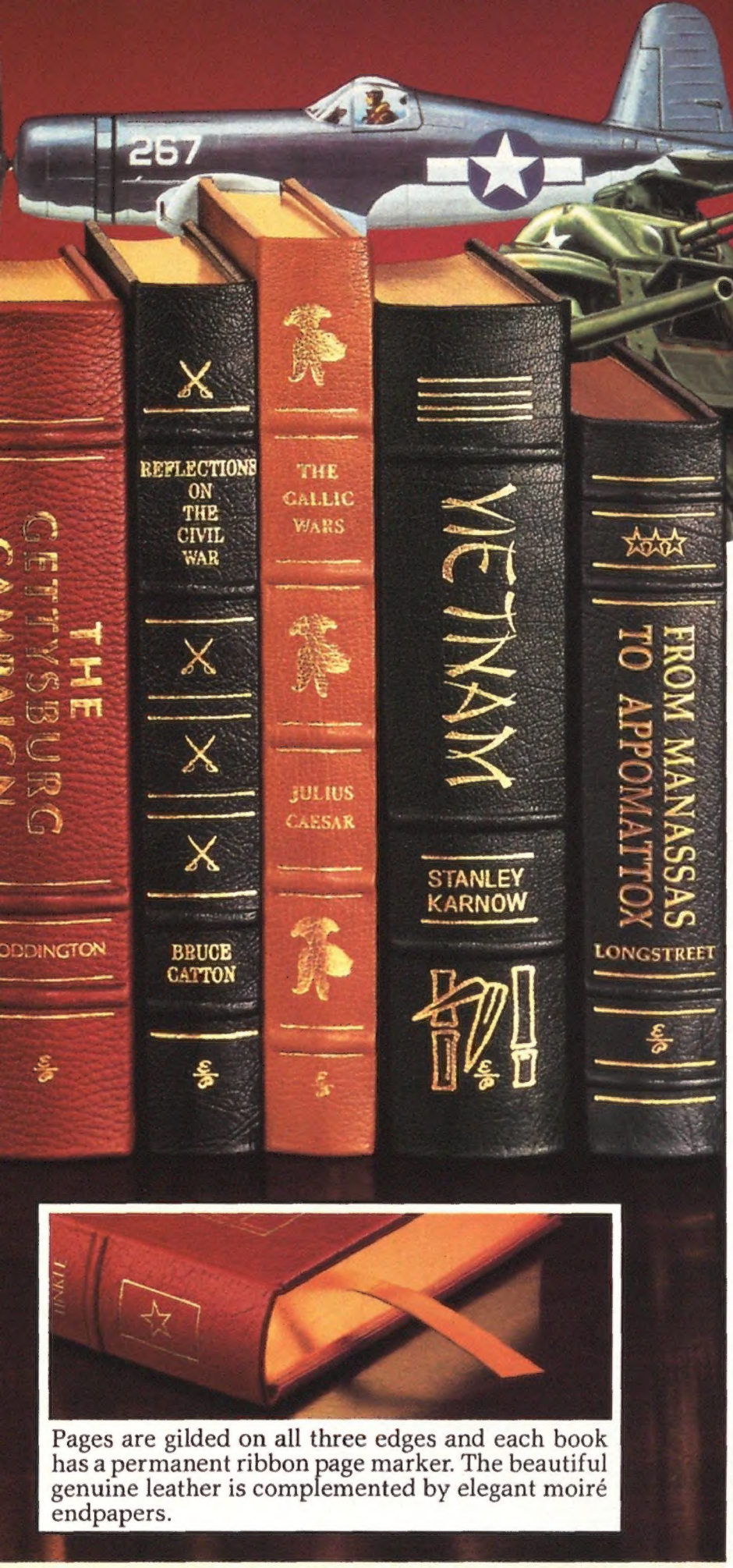

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A Hundred Thousand Windows

In 1982, with the completion of its first archival videodisc, the National Air and Space Museum began a program to manage and preserve its archives of photographs and documents. With patience and persistence, the project team continued the painstaking transfer of images from their original state to laser-readable code on a durable videodisc, and now this mass of information constitutes a national treasure of astonishing dimension. In March, the fifth disc in the series was completed and will soon be available to the public.

The conversion of archival photographs and documents into permanent, durable recordings that anyone with a machine of modest cost and complexity can reproduce will increase public access to the archive while enabling the archive itself to be preserved. Prior to the introduction of this technique, scholars visiting NASM could only rummage through original photographs and documents, and the cumulative damage of years of handling threatened the entire collection. Now the original photographs, slides, and transparencies can be placed in storage and preserved almost indefinitely. And the process of conversion produces a new collection of negatives that serve as backup duplicates of the original images.

The latest disc contains historic NASA archives, including the unique 70-mm photographs shot with hand-held cameras by the astronauts on shuttle missions STS-1 through STS-61. The series sets some important precedents. It is the first disc to include color transparencies—the 70-mm film offering the highest quality images, the first to be produced from an archive not operated by NASM, the first to be produced from a source outside the Museum, and the first to be completely indexed—an achievement that will provide easier access for scholars and researchers.

The NASA videodisc has been in production for two years. Use of two cameras—one for black and white and another for color—speeded the reproduction process, and creation of the index was by far the greater chore. A videodisc has the capacity to store 100,000 images, about the equivalent of 33 five-drawer file cabinets. Although the index occupies part of the NASA disc, there's enough room for more than 94,000 photographs that document programs from aeronautics to the space shuttle. When the videodisc is inserted into a player, the user can scan rapidly through the entire body of images or locate specific frames by number. A black-and-white print can be made for about two cents.

The first two discs in the series contain the NASM aircraft photo collection along with some documents. The third and fourth include the Air Force photo archive; disc four is still in the works and will be completed later this summer. Next to be produced are the images from Apollo, Surveyor, and Ranger spaceflights, followed by the Wright Field collection, which includes historic images of test and evaluation activities. NASM is gaining regard as a national center for conversion of image archives to videodisc storage, and both the Air Force and NASA archivists sought out the Museum's expertise in this technology. Other collections may find their way here as well.

Future plans call for application of more advanced technologies, including high-resolution video as well as digital recording, which offers exceptionally high-capacity storage for text. (Digital discs record the characters in a text rather than the image of the document itself.) The day when entire libraries can be scanned on disc may not be far off.

The successful use of this new medium has made it possible for museums and libraries worldwide to offer duplicates of the NASM archives to their own visitors, and many institutions come to regard the disc collections as part of their own archives. The entire NASM videodisc series is also marketed to the public through the Smithsonian Institution Press. With the publication of each new edition, another hundred thousand windows on NASM are opened for all to enter.

—Karl P. Suthard is the Chief of Information Management at NASM.

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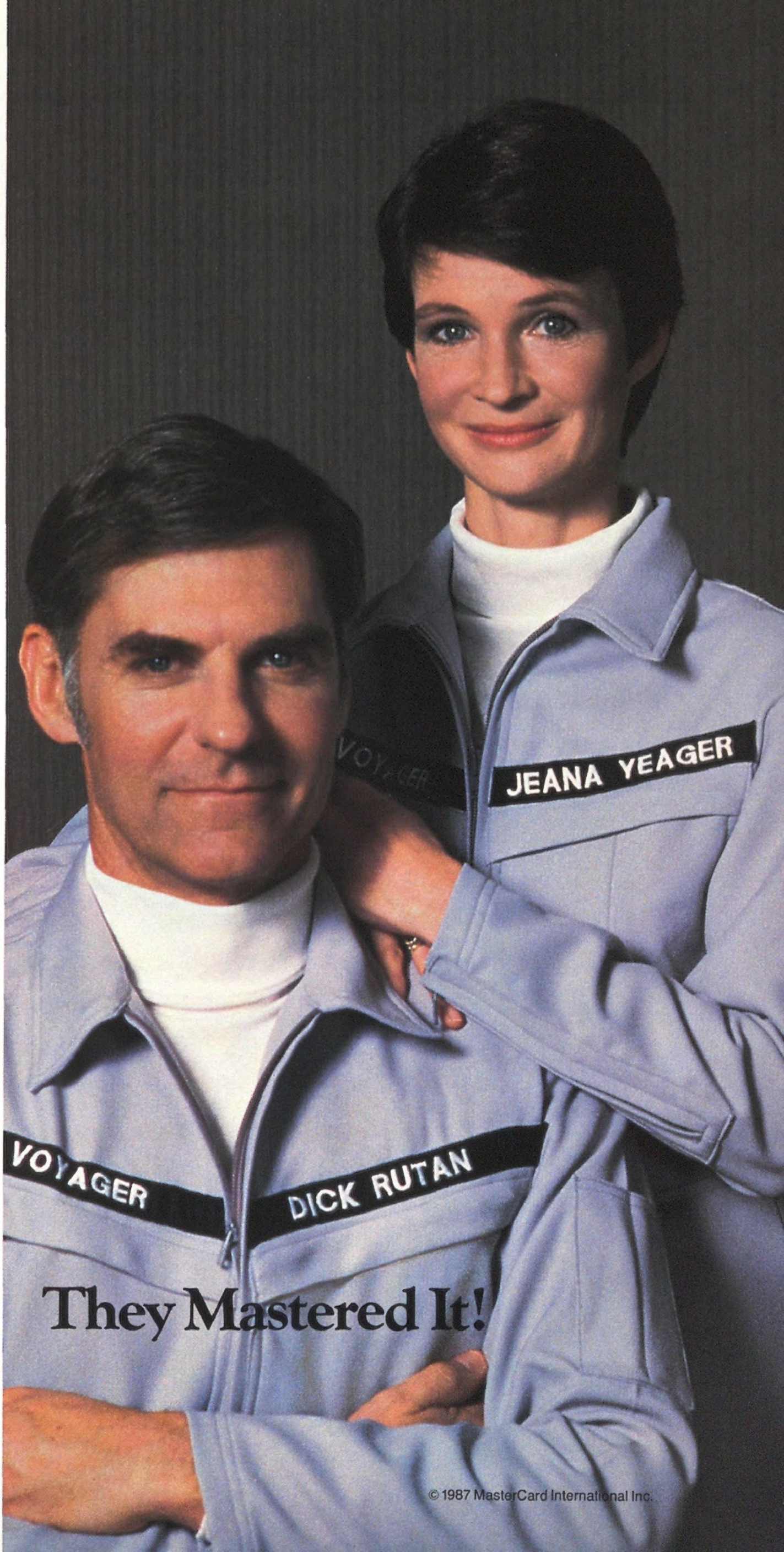


Letters

Right On, Private Sector

I agree with the essay "Clearing the Sky" (February/March 1987). The potential for the use of Earth satellites is unlimited. Private industry already uses these satellites in many different ways: television, weather, mobile telephones. Mr. McElroy is correct in suggesting if government restrictions were lifted and private industry became more involved, the benefits would be astounding.
Michael Calhoun
Union Bridge, Maryland

No Muss, No Fuss

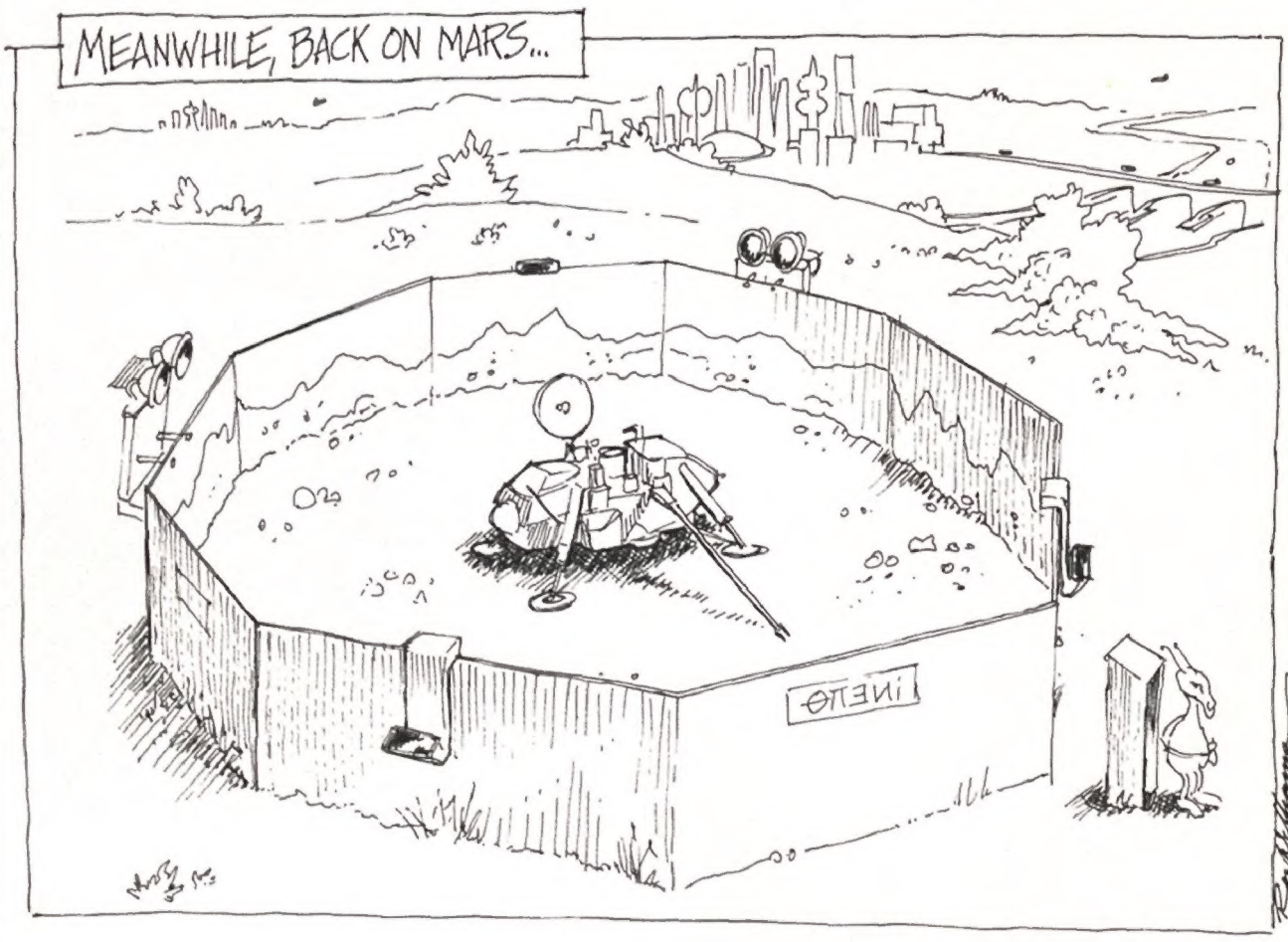
I read "The Little Airline of the Lake" by Margaret Engel (February/March 1987) with more than just a passing interest. As a manager for Meier's Wine Cellars on North Bass Island, I have had more than just an acquaintance with Island Airlines.

My first encounter with Island Airlines was four years ago. Upon arriving at the airport we were immediately ushered to the plane. No ticket lines, no fuss, just service.

I would like to say that in all my dealings with the staff of Island Airlines, I have found them to be professional. They may not have the accouterments of Pan Am or Delta, but these pilots are a breed apart. I'll fly with them anytime.
Gary Tartaglia
Cincinnati, Ohio

Respect for the Champion

Regarding the item reporting my flight, "Flying the Oregon Trail" (Soundings, February/March 1987), your readers might wonder why on Earth I stopped at 80 airports between Independence and Oregon City. Once every 25 miles is a bit much even in an Aeronca Champion. We actually used 23 airfields (I hesitate to use the term airport for some of them). The remaining



57 covered the flights from the East Coast to the West Coast and back. Over the 7,500 miles flown, we averaged 95 miles between stops, a more respectable endurance figure for the Champion.
Maurice Brett
Baldock, England

Moments and People to Remember

I wish to congratulate you on the beautiful article "Dash 80" by R.G. Thompson in the April/May 1987 issue. I have now read it twice and find myself poring over portions of it even a third time. The article is well written and must have taken many hours of research.

I was at the Boeing Renton plant on July 15, 1954, when Tex Johnston flew the Dash 80 over us. All employees were relieved of their duties for a few moments so that they might see the Dash 80 in flight. It's a moment that I'll always remember.
Wilbur W. Betts
Seattle, Washington

My compliments to you on the "Dash 80" article. The pictures and text blend well. Mr. Thompson did an excellent job of giving the airplane the starring role while weaving in the human participation.

In spite of Mr. Allen's acumen regarding jet air transportation's future, it never would have occurred without highly skilled engineering and manufacturing personnel: Wellwood Beall, George Schairer, Ed Wells, Maynard Pennel, William Cook, and Bob Reagan. While the crews experienced dangerous and sometimes damaging flights, these men agonized over the contretemps that occurred, but continued to solve the difficulties and proceed with new developments.
Richard L. Loesch Jr.
Seattle, Washington

Editor's note: Richard ("Dix") L. Loesch Jr. served as one of Dash 80's test pilots.

Flat Moon Society?

In your February/March 1987 issue, starting on page 22 you have a calendar of anniversaries and events. Why was the moon landing of July 21, 1969, left out? This is a large omission. Could it be that your publication believes, like my husband, that it never happened?
Mrs. W. Wilton Little
Roanoke, Virginia

Editor's reply: Each issue's calendar lists

anniversaries and events that relate to that issue's duration. In the issue that you mention, only anniversaries that relate to February and March of any year are listed. The moon landing, had we chosen to list it, would have appeared in a June/July issue.

However, readers should note that because of the rich diversity of air and space milestones, obscure events are sometimes chosen at the expense of blockbusters. Otherwise, we would be repeating the same events each year.

Celestial Rush Hour

Your story in the April/May 1987 issue "Eyes on the Sky" and the sky chart made it one of the most interesting and really informative stories to appear thus far in your publication.

The mention of collisions between satellites and various pieces of space debris makes one wonder: How can objects, all the same distance from Earth, where orbital speeds are the same, collide with each other? Are they all at such different angles of orbit that their paths intersect?

Also, the computer image of the Earth surrounded by objects in space (page 49) must be way out of scale, or incomplete. Most of the satellites shown in the sky chart are in geosynchronous orbit, about 22,000 miles from Earth, which should be almost three times the Earth's diameter of 7,926 miles. The picture does not seem to go that far out. Are there really as many objects as close to the Earth as depicted, and why were the more distant satellites omitted?
Louis H. Eisen
Oceanside, California

Editor's reply: Don Kessler of Johnson Space Center in Houston says that not all those objects in orbit follow the same orbital paths, nor do they orbit in the same direction—thus the potential for collision.

On the accuracy of the computer image: it merely illustrates the volume of objects orbiting Earth. Each dot represents one object but not to scale and not with precise relationship to actual altitude (which is impossible to render within the magazine's two-dimensional constraints).

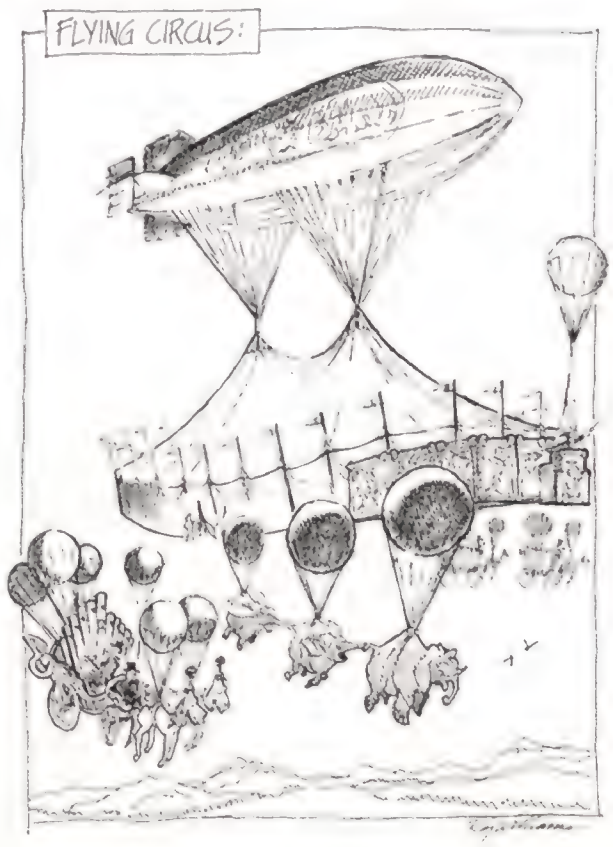
Kessler suggests that for further information, readers should consult the proceedings of COSPAR (Committee on Space Research) orbital debris workshops published by Pergamon Press.

I enjoyed "The Satellite Sky" and I commend you for the considerable research and design effort that went into it. I did detect what I believe is an error and a bit of creeping chauvinism, though; the Intelsat satellites are color-keyed United States. Intelsat is an international consortium of telecommunications ministries or other authorized national signatory agencies (Comsat, in the case of the United States). Perhaps in future editions of the chart Intelsat could be represented by its own unique color code, as was ESA, another international organization.
Ralph T. Johnston
Seattle, Washington

Editor's reply: The Intelsat series of telecommunications satellites was coded to indicate U.S. origin because all were launched from the United States. But they are operated by an international agency in which the United States exerts a strong influence. Satellite expert Saunders Kramer believes the coding as shown comes closest to reflecting reality.

Regarding "Eyes on the Sky" by James Oberg (April/May 1987), I've been wondering: Recently I read about planned launches of deceased bodies into space. Considering what I read in Mr. Oberg's article [about the danger from orbiting debris], is something being done to prevent this?
Mary Della Fera
Cape Coral, Florida

Editor's reply: We're not aware of any plans to launch bodies into space. However, there is a company in Florida, the Celestis Group, that plans to launch a satellite carrying cremated remains (called "cremains") into space. The Celestis Group plans to pack the ashes of cremated bodies into tiny cubes, which would then be loaded into a small satellite, about the size of a filing cabinet. The satellite would be launched by an unmanned rocket into an orbit about 1,900 nautical miles above Earth. Satellites do not use this orbit, so there should be no danger of collision.



The Celestis Group's plan has been reviewed by a federal interagency group that includes the National Aeronautics and Space Administration, the Department of Transportation, and the Department of Defense, all of whom have agreed that this "mission plan" is acceptable. The State of Florida has looked into the Celestis plan and has given it approval, according to the company that will launch the satellite, Spaces Services, Inc. For a lighter look at the matter, see "Dollars from Heaven" in the June/July 1986 issue of Air & Space/ Smithsonian.

The First of the First

In the December 1986/January 1987 issue you state that the Jet Propulsion Laboratory's WAC Corporal rocket was the first object to rise above the Earth's atmosphere, on September 26, 1945. However, that is incorrect.

The first object to rise above the Earth's atmosphere and into the area now considered "outer space" was a German V2 (A4) rocket, which reached an altitude of 53 miles on October 3, 1943, before falling into the North Sea near Denmark. All of those present at the time (including Werhner von Braun) were aware of the significance of their accomplishment and have gone on record as noting that they consider this date to be the birth of the first spaceship.

I look forward to finding your magazine in my mailbox every two months. Keep up the good work.
Kevin Cousineau
Tahcahapi, California

Editor's reply: You are closer to the mark than we were. According to Walter R. Dornberger's book V-2, *the Germans did indeed launch a V-2 that exceeded an altitude of 50 miles—but in October 1942. Dornberger's book (Viking Press, 1954) provides the anecdotal details of this pioneer flight.*

Air & Space/Smithsonian *welcomes comments from its readers. Letters must be signed and may be edited for publication. Address letters to* Air & Space/Smithsonian, *National Air and Space Museum, Smithsonian Institution, Washington, DC 20560.*

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The Little Yellow Airplane

The airplane glided in over the trees with a whisper, the propeller spinning silently as the nose rose slowly and all three wheels touched the grass. After rolling a few yards it turned and taxied to a small hangar and a group of people waiting there.

I stood straddling my bike across from the grass strip where the pilot was unloading his passenger. I'd never been so close to a real airplane before. A hand-painted sign by the road skirting the little strip proclaimed "AIRPLANE RIDES $2.00." There were quite a few cars parked beside the hangar and people chattered excitedly, awaiting their turns.

I'd been riding my bike through the low hills north of Tampa looking for a promising spot for large-mouth bass when the airplane swooped down, just over my head, and disappeared behind a stand of tall pines. Fascinated, I followed the noise to a rutted road paralleling a runway. I hid among the trees and watched the pilot load a passenger in the front seat, then climb in the back. With a low purr the airplane spun around and pulled out onto the runway. The tailwheel rose, and for just a second the buttercup-colored aircraft rolled along perched on the front wheels. Then, in a fluid motion that thrilled me no end, it rose slowly and climbed out of sight.

I got off the bike, leaned it against a tree, and sat down with a clear view of the strip. About 10 minutes later I heard the sound I was waiting for. The airplane reappeared in a gentle descent. There was no engine noise—just the whoosh of air through the struts as the airplane settled into another perfect landing. I sat there enthralled for the rest of the afternoon, wishing for all the world I had two dollars.

As dusk approached the last of the customers departed. I watched the pilot lift the tail and drag his airplane to the hangar, push it in, and slide the door shut. As he turned to his car he paused a moment and stared in my direction, shading his eyes from the setting sun. I thought he might chase me away, but he got in his car and drove off without a word.

Suddenly I realized it was getting dark. My mother would be upset—I never came in late from my fishing excursions. I frantically pedaled the 10 miles back to the city. It was dark by the time I got home.

"Sorry, Mom," I blurted as I rushed to the table. "I forgot the time."

"Where were you, son?" She sounded stern. Dad just glanced at me and continued eating a piece of fried chicken, our standard Sunday dinner.

"Up north, by the dam. Guess I was farther than I thought."

Illustrations by Susan Davis

"Fishing good?" my father asked, not looking up.

"Uh, no sir, it wasn't. Didn't catch a single one."

He raised an eyebrow. At age 13, I was a fairly good fisherman. "Next time you leave earlier whether they're biting or not," my mother said.

"Yes ma'am." I hadn't exactly lied—after all, I hadn't caught a fish. Of course I hadn't gotten a line wet either.

The following Sunday Mom packed me a sandwich and an apple and I was off for another fishing trip at the airport. All day the little yellow airplane came and went. Once as it rolled past I thought the pilot waved at me. I waved back, then felt foolish—Why would a pilot wave at a kid?

The weeks went by and I never missed a Sunday. The pilot waved occasionally; I could see his smile when I waved back.

I made sure I was always home by dusk. My parents were perplexed by my persistent lack of fish, but they said nothing and seemed content with the explanation that I was out exploring on my bike.

One evening I asked my father if there was any way I could earn two dollars. He shook his head. "Not now, son. I'm sorry." It was the summer of 1947, and he had just suffered a business failure. Money was tight—we were living in a tiny one-bedroom cottage. Even with Dad's two jobs, there was talk of Mom's going to work. I just couldn't ask them for the money.

I had no luck in trying to get a paper route, and the grocery store didn't need bag boys. But I was determined to get the money for an airplane ride.

One Sunday, as I sat watching the airplane flutter overhead, a thunderstorm blossomed over the hangar. The sky turned dark, and as the customers by the hangar bolted for their cars, the huge raindrops of a sudden Florida storm splattered down. I nestled under the thickest trees as the storm strode on. The sun reappeared, but not the passengers. The pilot came out of the hangar and peered at the sky, then turned and surveyed the empty parking lot. He started for the airplane, then stopped and looked in my direction. My heart thudded as he strolled over. Was he, at last, going to run me off? Was I doomed to return to bass-hunting every weekend?

He stopped a few feet away, and I respectfully rose. A strapping figure, he wore riding pants, brown boots, and some kind of military shirt with epaulets. The most impressive embellishment, however, was a huge handlebar mustache.

"Well, the rain didn't drive ya off, eh lad?" He had an accent I didn't recognize—British, perhaps.

"No sir, it was dry here in the trees." Almost as dry as my throat.

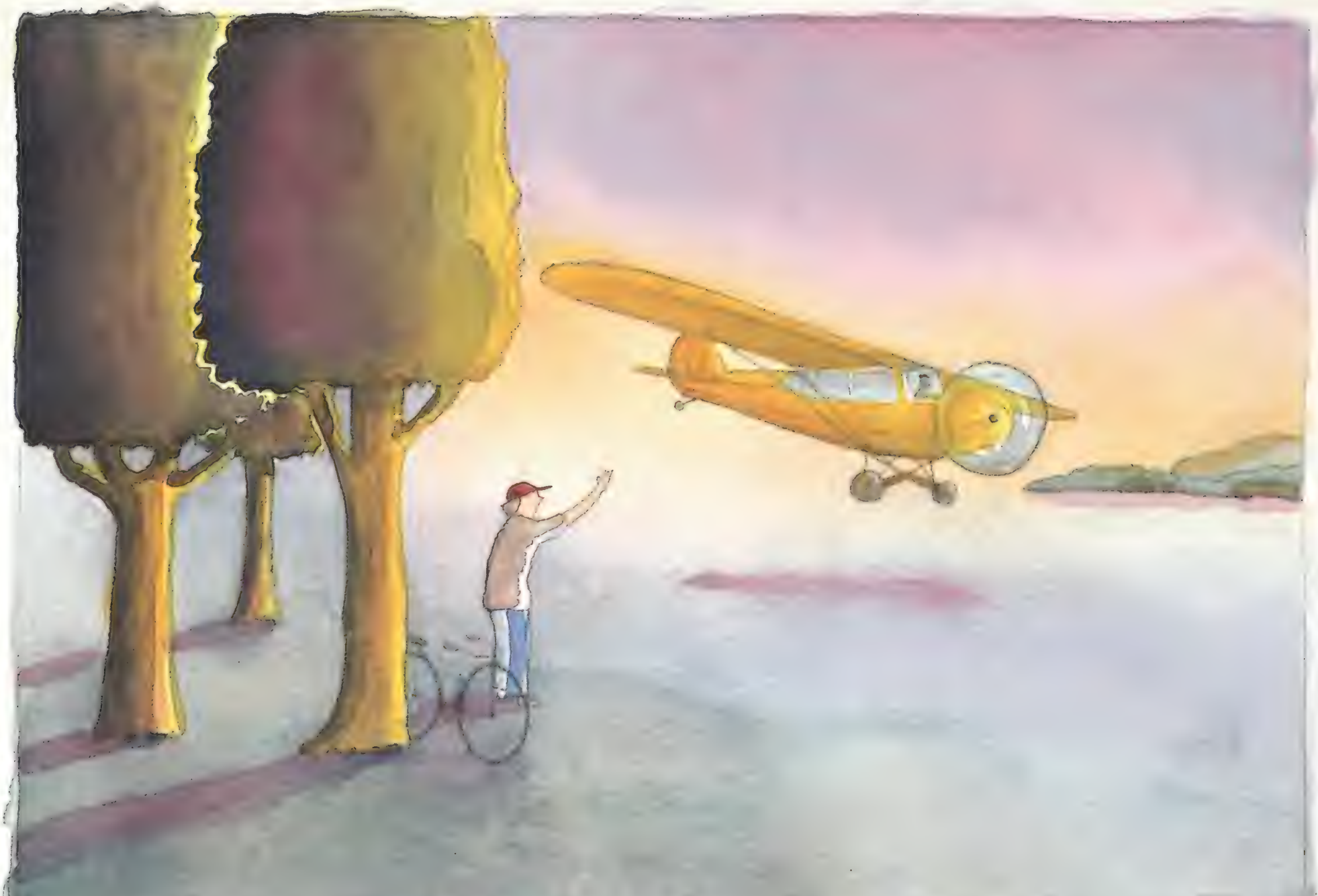
"Ya come here every Sunday, lad?"

"Yessir."

"Do ya like my little Cub?"

"Cub, sir?"

"Yeah, lad, my plane—it's called a Piper



Cub. Ya like 'er, eh?"

"Yessir, I do. It's a lovely plane."

"Have ya flown before?"

"No sir!"

"Well, I need 'er washed. How about doin' that for me and we'll take a spin to dry 'er off."

"Yessir, I'd like that!"

He led me across the strip to the Cub. As he showed me where to wash, I ran my fingers over the fabric. I was actually touching an airplane!

He produced a bucket, soap, and a clean rag. Never has a machine received the tender loving care the Cub got that magical afternoon. I had done the entire airplane, inside and out, and was redoing the belly when the pilot reappeared.

"Aye, lad, that's enough. You'll wash off the paint," he chuckled.

"I was just trying to get the belly a little cleaner, sir."

"It's fine, just fine. And what's your name?"

"Jack, sir. Jack Doub."

"Jack, eh? Well, my name's McCook—you can call me Sandy. Help me swing the tail around, Jack, and we'll go fly."

Once we had the Cub pointed toward the runway, he helped me into the front seat and adjusted the seatbelt. He pointed out the instruments and controls, and I marveled at how a man could learn all these things. Mr. McCook must be a very smart man indeed, I thought.

With a flip of a hand he spun the prop and the engine hummed to life. After climbing in the back seat, which contained the primary set of controls and gauges, he pulled the chock from under the right wheel and cast it aside.

"Here we go, lad!" The Cub rolled toward the runway. I was vaguely aware of the tail coming up, and then suddenly we were in the air and climbing, the trees slipping away beneath us. I was flying!

"Great, ain't it?" Sandy bellowed over the engine noise. I could only nod.

We leveled off at 2,000 feet and flew around the edge of the city. To the south I could see Tampa Bay and dozens of tiny lakes. It was an enchanted moment.

All too soon we were landing on the little grass strip. The propeller ticked to a stop while I sat in the airplane, relishing the final seconds.

"Are ya okay, lad?"

"Yessir." Reluctantly, I crawled out of the Cub. "I'm going to be a pilot someday, sir, just like you."

"Good! We need smart, hard-working fellows like you in aviation."

The sun was setting—time to start for home. I ran across the strip to my bike.

"Jack!" Sandy called. "See you next Sunday, then?"

"Yes SIR!"

I made it home just before dinner. I noticed Dad eyeing me several times, but thought nothing of it. Later, as I sat in my room drawing pictures of the Cub instead of doing my homework, I was suddenly aware of him standing there. He sat down on the edge of my bed. "What happened today, Jackie?"

I studied him for a moment. It would never occur to me to lie to my parents, so highly did they value honesty. With some trepidation, I told him the whole story. "I'm going to be a pilot!" I ended up declaring with all the conviction of my young years. A smile played at his lips, and he hugged me.

Nine years later Dad pinned Air Force wings on me. Since then I've flown supersonic fighters, commercial aircraft, and all sorts of recreational airplanes. But none compares to the little yellow airplane, whispering in over the pines on those lovely summer afternoons.

—Jack Doub

A ParaPhrased Design

"It's a little windy up there today."

Nathan Taylor tugged once, twice at the chin strap of his helmet, lifted the snug plastic shell from his head, and raked his fingers through his coarse blond hair. "It's not dangerous," he explains, "but for a first-timer, it might be a little uncomfortable. So I'll leave it up to you. Do you still want to fly?"

I wasn't sure. The two-hour videotaped lesson and multiple-choice quiz that preceded my ParaPlane flight contained a lecture from the company lawyer, warning that "flying involves travel in three dimensions, and such activity is subject to mishap, injury, and possibly even death."

The ParaPlane sat on the crewcut turf of a southern New Jersey sod farm, trying to look fierce enough to live up to those lawyerly admonitions but failing miserably. It resembled a lawn chair on wheels with a giant hamster wheel and two propellers stuck on the back. The improbable contraption was connected by a tangle of Dacron lines to a billowing 28-foot wing-shaped parachute.

ParaPlane designer Steve Snyder—also an aeronautical engineer, pilot, and parachutist—and engineer Dan Thompson created the aircraft in 1983 in an effort to fulfill the average person's desire to fly. So far, 10,000 average persons have tried it. Because the ParaPlane weighs only 160 pounds, it is designated an ultralight vehicle by the Federal Aviation Administration, and no pilot's license is required to fly it. "If you can tie your shoelaces," Snyder says, "you can fly the ParaPlane." And with a price tag of $5,795, it is available to thousands of shoelace tiers unwilling to spend ten times that for a conventional aircraft.

"It's a real winner," says Paul Hirschman, vice president of the Pennsauken, New Jersey company. "Right now we have more than a thousand units flying." Among the owners are rock 'n' roll/soap star Rick Springfield and the Smothers Brothers. "One has a canopy imprinted 'Smothers,' " Hirschman explains, "and the other says 'Brothers.' They have to be aware of who's flying left and who's flying right, or it comes out backwards."

Paul Salmon

"I remember the first time I flew the ParaPlane," Hirschman says. "I was nervous, but after a few minutes you relax. And you just want to stay up there."

Now Taylor, a ParaPlane instructor, stood ready to launch me from the sod farm on my first solo flight in any aircraft. Strapped into the squeaky padded plastic seat, I pulled the helmet down over my ears. Taylor yanked on the lawnmower cords overhead to start the two 15-hp engines, and the counter-rotating propellers

snarled to life, encouraging the parachute to balloon out behind us. "The lever on the frame, down and to your left, is the throttle," he reminded me above the din. "Pull all the way back to take off or gain altitude. Push it forward, slowly, to come back down."

Two foot pedals on bars in front of me, attached to either side of the parachute, would bank the ParaPlane left and right. The only instrument aboard is an altimeter to indicate when you have reached the aircraft's ideal training altitude. I was instructed to take off, soar to 500 feet, circle the field, perform a leisurely figure eight, then land.

Taylor backed up and gave me a thumbs-up signal to gun the throttle. The convex mirror between my feet showed the orange and white parachute rising like the ghost of a giant Creamsicle. Taylor studied it, then yelled, "Full power!" Slowly at first, then quickly, the ParaPlane rolled forward. In five or six heartbeats, I was rising noisily above a bank of trees.

Below, 18-wheelers rolled along Interstate 295. A farmer poked along on a tractor between waving rows of tall corn. Taylor's voice, crackling over the radio headset in my helmet, blasted me out of my reverie. "Pull away from the trees. Turn left. Throttle back."

If I hadn't listened up, the ParaPlane would have flown on, practically by itself, until the hour-long fuel supply of five gallons ran out. And if it had, I would have descended to a power-off landing at a gentle 7 mph. The ParaPlane is, after all, a glorified parachute.

I pushed the left foot lever, which offered stiff resistance—like a Nautilus machine with 100-pound weights. The ParaPlane responds to turn commands almost reluctantly. With a maximum speed of 26 mph, everything happens in slow motion, which makes it remarkably easy to fly. After angling into a figure eight, I dropped down to about 20 feet from the ground in a practice landing, then headed back up again, dangling like a hypnotist's pocket watch and appropriately mesmerized by the view. I had seen the Earth from that vantage point before, but always with someone else at the controls. Now I was realizing a lifelong dream to set my own course. And that's precisely what its designers intended.

"The ParaPlane is going to open up the door not to thousands but to millions who have always had the desire to fly," Thompson asserts. "All you have to do is fold it up and take it with you. That's the beauty of it." The ParaPlane—manned flight to go.

—Jeff Meade

Crossing the Potomac on a Ring and a Prayer

Historians say the story about George Washington throwing a silver dollar across the Potomac River doesn't hold water: if it occurred at all, it involved the Rappahannock River and a coin similar to a Spanish milled dollar. So Scott Zimmerman, seven-time Frisbee champion, and Alan Adler, the inventor of the Aerobie—The Astonishing Flying Ring—set out in mid-April to run rings around a Washington legend.

Adler, a soft-spoken electronics engineer and self-taught aerodynamicist in Palo Alto, California, spent eight years developing the Aerobie. Because the ring, an eighth of an inch thick and 13 inches wide, has one-third the drag of a Frisbee, it flies almost three times as far. What's more, it flies straight and level, due to a tiny lip on the outer edge of the upper surface that equalizes lift. The stability it induces makes the ring a snap to launch or catch. Adler gave a limited demonstration of its flight characteristics in a conference room full of NASA aerodynamicists, but they wanted numbers: lift-over-drag ratio; the ring's Reynolds number, an indication of its aerodynamic efficiency; the amount of liability insurance Adler's company carries.

The next day, after a game of catch in the halls of a Congressional office building, Adler, Zimmerman, camera crews, and the inevitable Aerobie-catching dog stood on the banks of the Potomac, contemplating the headwind. Zimmerman was dressed as a colonial: white wig and stockings, red vest, and black buckles on his Reeboks. The California State Polytechnic University student holds the world's record for any object thrown: an Aerobie, of course, for 1,257 feet (more than four football fields). "He's cost me a couple of grand in prize money already," Adler says. The latest $1,000 offer requires a throw of 1,320 feet. But today, Zimmerman wasn't attempting a record-breaking toss. He needed only to get an Astonishing Flying Ring across 500 feet of river.

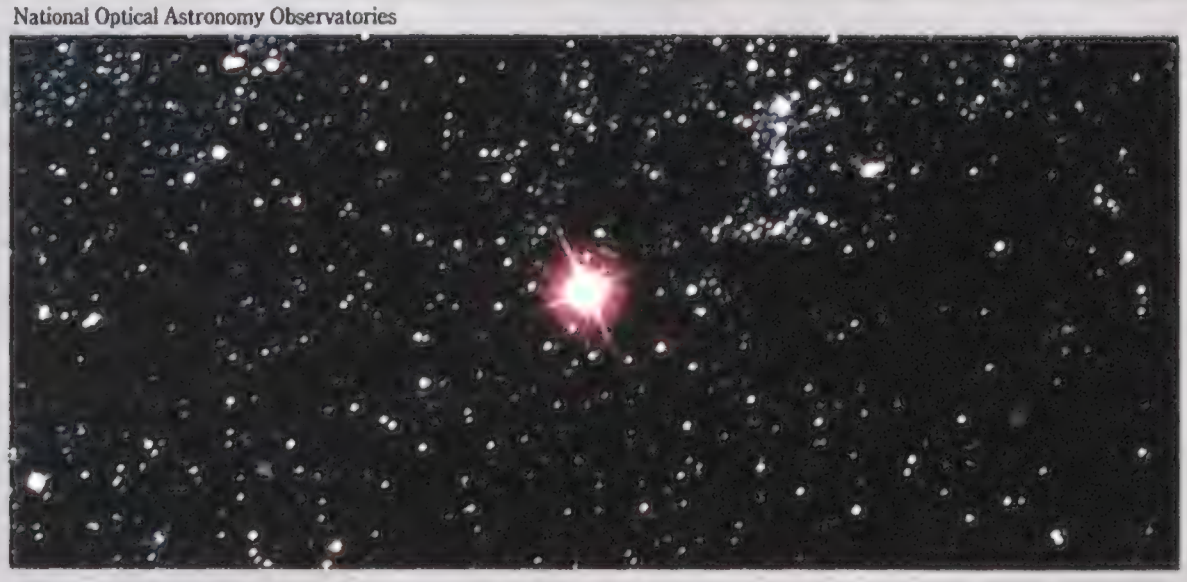
Zimmerman eyed the trees on the riverbank, took the mound, and hefted an Aerobie. The cameras whirred. With a modified pitcher's windup and three running steps, he hurled the ring. It ricocheted off a tree branch, soared about 1,000 feet downstream, and plopped into the Potomac.

No matter—Adler had brought boxes full of Aerobies. Zimmerman was handed another. This time it whirled over the river and landed in a tree on the opposite bank. The spectators applauded—but this was just a warm-up.

With industrial tape, Adler affixed a silver dollar to the top of an Aerobie. After a few short test flights, Zimmerman dug in and let fly. The ring wobbled across the river but fell short of the bank. At $10 per coin, Adler lost only $30 before Zimmerman succeeded in getting one to the other shore.

Mission accomplished, Adler opened a

National Optical Astronomy Observatories



Star Light, Star Bright

The supernova of February 24 blew away gases, radiation, and previous theories. The explosion of what scientists have tentatively identified as Sanduleak is providing the first good look at the death throes of a star.

To date, it has raised more questions than it has answered. Scientists are puzzled by the lack of brightening they think should have preceded the explosion. They had expected the progenitor to be a red star, but Sanduleak was blue. "We're trying to learn as much as possible as quickly as possible," says astrophysicist John Bahcall. "This is a very special time."

fresh box of Aerobies and invited the media to try their luck. Bright red rings fell like rain before the supply and the reporters were exhausted.

"Maybe we'll do Niagara Falls next," Zimmerman says. "We'll see," says Adler. "You can do too much of this sort of thing—people get tired of it." With Aerobie sales upwards of two million and climbing, nobody's tired yet.

—Patricia Trenner

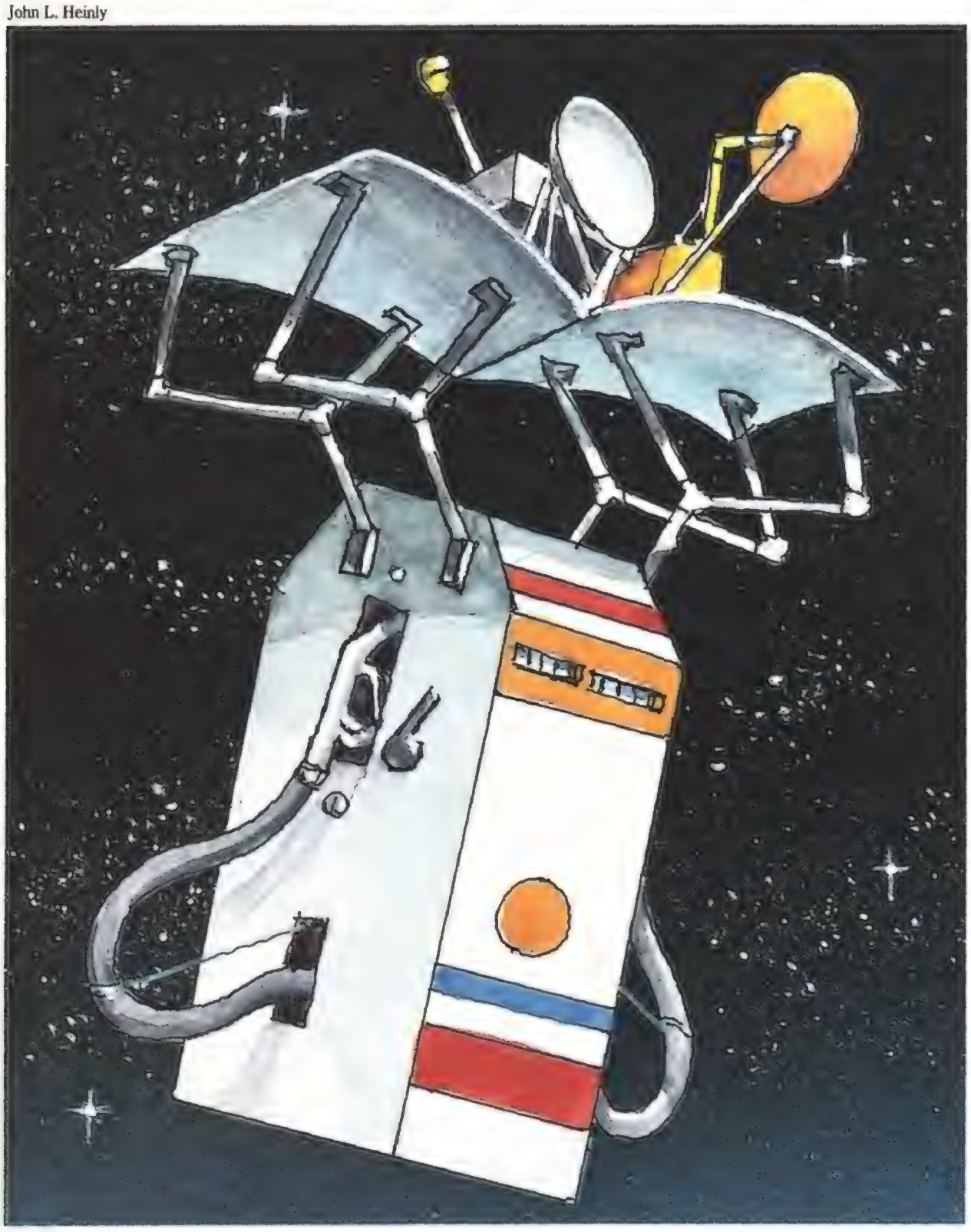
Satellite Service Station

It will not wash the windows, check the oil, or take credit cards. It will, however, pump fuel.

The orbital refueling station in the works at the National Aeronautics and Space Administration could keep satellites and space stations aloft indefinitely. Without fuel, spacecraft can only remain in orbit for a limited time, as the demise of Skylab illustrated. Depending on size and altitude, within a few years their orbits slowly decay and eventually they plummet into Earth's atmosphere.

Long-term projects such as the space telescope, materials processing, and the space station will only be effective if they can be regularly supplied with fuel and other lifebloods, such as high-pressure gases and supercoolants. Project contractors are designing tanker systems that can be operated from the shuttle cargo bay, from platforms on a space station, and from a space ferry that will extend the tanker's range. And during the refueling process, which is estimated at several hours, astronauts can remove and install experiments and retrieve space-manufactured products.

John L. Heinly



Space tugs to refuel satellites in the 22,000-mile-high geosynchronous band could be operating from a space station by the end of the century. Presently, the communications satellites that make up the bulk of traffic in that highly commercial band cannot be refueled or retrieved for repair.

Orbital refueling is nothing new—the Soviets have been servicing the Salyut space stations for almost 10 years. The United States' first refueling test was conducted in the shuttle's cargo bay during an October 1984 mission: astronauts transferred hydrazine from a mockup tanker to a mockup satellite.

The first bona fide refueling is scheduled for 1992, two years after the proposed launch of the Gamma Ray Observatory spacecraft. The prototype refueler will be operated by an astronaut riding on the shuttle's robot arm and will refill the NASA satellite with 1,800 pounds of hydrazine. TRW, the satellite's manufacturer, is fitting it with the necessary couplings for the transfer.

None of today's satellites are designed to couple with a refueler—they would have to be retrofitted in orbit. What is needed, some researchers say, is standard hardware on all new satellites that matches couplings on the refueler. "There must be a community effort between the users and the suppliers," says Thomas Berry, program director for the orbital refueler project at Fairchild Space.

However, by the time a satellite runs out of fuel, it is often considered obsolete. Operators, particularly those with imaging satellites, say they would rather put their money into building better satellites than into refueling outdated ones. It's a safe bet that until satellite operators and orbital service station owners reach some sort of agreement, the lines at the pumps won't be very long.

—Barry Rosenberg

The Heart to Fly

Only a medical certificate stood between Andrew Craze and his first solo flight. But Federal Aviation Administration physicians evaluating his application for a pilot's license were skeptical. Could a 20-year-old heart transplant recipient measure up medically?

Craze received a new heart in 1983 after a disease called cardiomyopathy destroyed his. Two years later, as a freshman at Stanford University in California, he joined the Stanford Flying Club. "I told my instructor up front, 'I've had a heart transplant,' expecting a hassle," Craze recalls. "But he was real positive about it.

He said if my doctor okayed flight training, so would he. The only problem he saw was in pushing it through the bureaucracy."

By the middle of his freshman year, in January 1986, after 17 hours of dual instruction, Craze was ready to solo. All he lacked was the medical certificate.

The first step was a physical exam by the local FAA examiner in Los Altos. "One question on the forms was 'Are you on any medication?' " Craze says. "They gave you a square inch of space to write your answer. I needed a page. But I wrote it up tongue-in-cheek, like it was very ordinary."

The FAA made it clear his case was anything but. The agency generally prohibits solo flight for people with significant heart disease, although some coronary bypass patients have qualified. The standards do not specifically address heart transplant recipients, and only one other transplant recipient has applied for certification. He was turned down after suffering serious medical setbacks. Five cardiology consultants were called upon to evaluate Craze's application, which had scaled the bureaucratic ladder to the office of the Federal Air Surgeon in Washington, D.C. "They wanted all my medical records—everything since transplant surgery," Craze says. "I started to assemble it, but then I realized that sending *everything* would have been ridiculous—it's a stack several feet tall."

Last summer, he drove from his hometown of Cleveland Heights, Ohio, to FAA headquarters in Washington with an armful of electrocardiograms, stress test results, and lab reports. "I interviewed Mr. Craze," says Dr. William Hark, manager of Aeromedical Standards for the FAA. "He came to Washington to show us that he's doing very well—he's a healthy-looking young man."

But the FAA doesn't base its decisions on appearance. It took a flurry of letters and calls from Sharon Hunt, Craze's cardiologist, to convince the agency's doctors that his new heart was no deterrent to safe flight.

Last October Craze made history as the first heart transplant recipient to receive an airman's medical certificate. On December 9, he made the traditional three solo takeoffs and landings in a Cessna 150.

"The FAA was worried that a heart transplant patient might lose consciousness or even drop dead in flight," Hunt says. "But transplant patients aren't likely to have heart rhythm disturbances or die suddenly. We do lose some transplant patients, but with plenty of warning—usually to pneumonia or infection."

The FAA requires Craze to report on his condition twice a year, as often as airline pilots. Meanwhile, Craze is trying to convince his mother that airplanes are as reliable as his new heart seems to be.

—Patricia Herold

John L. Heinly

Gilt Trip

Stokely Outdoor Advertising knows how to dress for success—or maybe excess. The Tulsa, Oklahoma helicopter operation has done up a Robinson R-22 helicopter in gold leaf for about $13,000. That's about four times the cost of a standard paint job. But then, Bill Stokely wouldn't have much of an advertising company if he stuck with standard promotional practices.

"We do anything that's legal to do with a helicopter," says Brian Merkle, operations manager. The company rents the Robinson to radio and television stations for traffic reporting and news coverage, and claims the gold leaf finish provides high visibility and instant recognition for Stokely clients. "It's very pretty," Merkle says, "especially in bright sunlight. People are glad to see something out of the ordinary."

Tulsa businessman Carl Burke, who has gilded some of Liberace's pianos, was hired to apply the 23-karat gold leaf. The helicopter first received a base coat of yellow paint, and the gold layer was sealed with a special varnish. Despite the high-priced spread, the finish is no more susceptible to weather damage than the paint on your car. "Gold is the most resilient substance known to man," Merkle claims.

When he's not sending it out for publicity, Stokely uses the helicopter for flight instruction. "But we don't let students solo in it," Merkle says. It's said that God looks after fools and student pilots, but Stokely isn't taking any chances.

—Patricia Trenner

If Pigs Had Wings

Frequent fliers know the feeling well. The airplane suddenly dips a wing, and passengers grab for an armrest and their drinks. Weather is often the cause of the turbulence, but there are times when an elephant may be the guilty party. Stranger things have been shipped in the belly of an airplane.

"Elephants are difficult to handle—they have to be well restrained," says Bill Greenway, a former British Airways cargo manager. "They can rock an airplane simply by moving from one foot to another. We used to put chickens on the floor near an elephant—it wouldn't move for fear of trampling the chickens."

Years ago ships dominated the transoceanic cargo industry, but today airlines and air freight companies provide far more rapid transit for flora and fauna. Fresh produce, trees, sheep, and pigs regularly appear on air cargo manifests, and some require nearly as much attention as the passengers.

British Caledonian Airways is one of several airlines that transports dolphins, which must be flown out of water. They are covered with oil to keep their sensitive skin moist and suspended in hammock-like harnesses. The mammals are usually accompanied by their trainer, who provides

moral support during the flight.

Japan Air Lines excels at flying tuna from North America. The fish are transported at 32 to 50 degrees Fahrenheit in refrigerated containers. In-flight temperature is critical—in Tokyo, frozen tuna brings a much lower price than fresh.

Air France has operated cattle charters, flying up to 100 tranquilized bovines out of Canada. And Transamerica Airlines helped start up an Alaskan dairy industry by flying 90 Holsteins to Anchorage in a DC-8.

In the late 1950s, British Overseas Airways shipped monkeys to the United States to be used in the development of a polio vaccine. The animals, which were loaded in Malaysia and the Philippines, often broke out of the flimsy cages and hid in recesses between the aircraft skin and the cargo hold liner. It was often impossible to lure the monkeys out until they were hungry.

In the late 1970s, two baboons escaped from their pens at the Northwest Orient cargo terminal in Los Angeles. "They got loose in the warehouse and then walked up the stairs to the second floor," recalls Rene Vergara, a sales manager for Aeromexico. "There was some talk about trapping them ourselves, but when we saw the size of their teeth, we changed our minds." The ASPCA spent eight hours and numerous tranquilizer darts capturing the wayward passengers.

Boa constrictors and other snakes are not terribly cooperative travelers, either. On a flight from South America to London, a snake got loose in the temperature-controlled cargo hold of a British Airways freighter. When the aircraft stopped in Madrid, employees spotted the wanderer after some cargo was unloaded and immediately closed the hold door. Upon reaching London, they cautiously opened the door, but the snake was no longer a threat: it had wriggled into a recess between the inner and outer walls of the hold and had frozen.

—Gary Stoller

Cheap Thrills

Mickey Mouse, meet R2-D2. Disneyland and George Lucas have combined pop culture and computer technology in a flight simulator that's become the hottest Disneyland attraction since Space Mountain.

The use of simulators is now so widespread that most pilot training can be done on the ground. Simulators and software duplicate the visual cues and motion of flight with an eerie accuracy, making a ground-bound session almost indistinguishable from the real thing.

Walt Disney Imagineering and Lucas simply took the technological ball and ran with it. Working with the Rediffusion Simulation Company, which builds flight simulators for the airlines and the military, they created Star Tours, a souped-up simulator enhanced by 70-mm *Star Wars*-type images.

At the Anaheim, California park, Star

John L. Heinly

A Hughes Aircraft Company Value Engineering Change Proposal (VECP) significantly improved the design of a power control unit used on the M1 Abrams Tank and Bradley Fighting Vehicle and led to a savings of $9.09 million for the U.S. Army over the life of the two programs. Hughes improved the power control unit's reliability and producibility by calling for changes in three circuit board modules. The result was fewer components, an increase in electrical efficiency, and a reduction in the number of spares needed. Ongoing participation in value engineering programs resulted in the Army Material Command awarding Hughes the Outstanding Achievement in Value Engineering Award for 1985.

Spectacular nighttime rescue aided by Hughes' Nightsun® searchlight, the most powerful searchlight ever developed for lightweight helicopters. When an aerial gondola cable linking Sentosa Island with Singapore was damaged by a towed oil rig, panicky passengers dangled high over the water in complete darkness. A police helicopter illuminated the scene nearly as brightly as the sun with the Nightsun searchlight, while a second helicopter rescued the passengers. The searchlight is built by Spectrolab, a Hughes subsidiary. It provides 30 million candlepower, as compared with the maximum 900,000 of ordinary searchlights.

A near-field testing system offers savings in excess of 1% of an antenna's value and allows troubleshooting on each individual element of an antenna. Hughes developed the system as a cost-effective, highly accurate way of testing many shipboard and air defense antennas. It is more practical than far-field testing and allows a greater degree of complexity than previous near-field test systems, while easily duplicating the test data that would be obtained by both methods. Housed in an anechoic chamber, the computer-controlled system moves a waveguide probe through measurement positions as close as a few thousandths of an inch within a 19x26-foot area. The probe position is monitored with a laser interferometer. Information on the antenna's vector radio frequency field is then measured and converted to equivalent far-field pattern data by the system's software.

Ground Vehicular Laser Locator Designator (G/VLLD) successfully carried out the first over-water operational test phase of the Swedish Coast Artillery Hellfire missile program as part of their coastal defense evaluation program. Designed and produced by Hughes originally for the U.S. Army, G/VLLD is a combination target locator, laser designator, and rangefinder. G/VLLD can focus a narrow-beam high-intensity laser on specifically vulnerable portions of the target so that laser-homing Hellfire missiles are virtually assured of a hit, even against moving targets at distances of up to 18 kilometers.

Support Systems in Southern California designs, develops, and manufactures some of the most sophisticated training simulators and a wide array of automatic and manual test systems. In addition, field engineering and technical support of a wide range of electronic systems keep Hughes' systems operating at top efficiency worldwide. Opportunities are available for a variety of engineers qualified by degree or extensive work experience. They include systems engineers, radar engineers, and software and hardware design engineers. Please send your resume to Lowell Anderson, Professional Employment, Dept. S9, Hughes Aircraft Company, P.O. Box 9399, Long Beach, CA 90801-0463. EOE. U.S. citizenship required.

For more information write to: P.O. Box 45068, Los Angeles, CA 90045-0068

HUGHES
AIRCRAFT COMPANY

Subsidiary of GM Hughes Electronics

Tours begins with a stroll along a catwalk in an intergalactic hangar where androids are tinkering with disabled spacecraft. Departure announcements are broadcast while interplanetary travel and dining commercials flash on a video screen.

Once the 40 passengers have boarded the StarSpeeder 3000 and cinched their seat belts, a flight to the Moon of Endor commences. The pilot, a lugubrious android named Rex, is an absolute rookie. He nearly crashes during departure, runs afoul of a meteor shower, dogfights with the forces of evil, and ends up in a dizzying high-speed run down a deep trench in enemy territory. Rex barely gets his shaken passengers back in one piece.

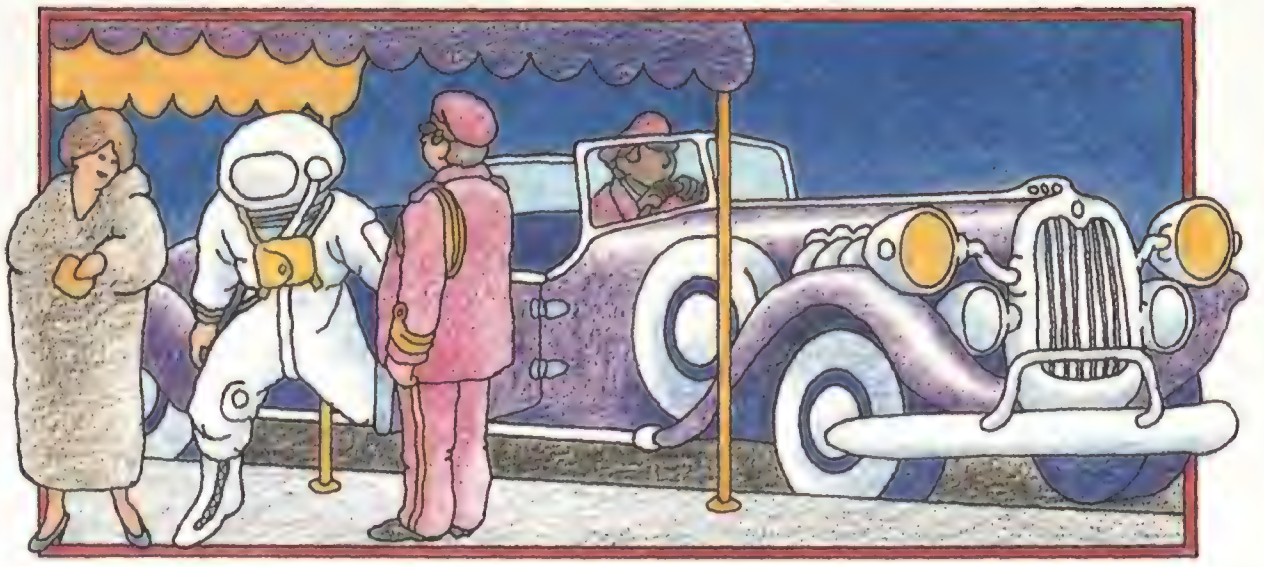
The ride is an intense five minutes laced with jolts of up to three Gs and a stomach-churning rush as "hyperspace speed" is attained. Lucas' visuals are synchronized with violent jerks, abrupt stops, and swaying so wild that passengers occasionally lose their glasses.

Disney's not saying exactly how the hydraulically controlled simulator was modified into Star Tours. But because the electronic checks and balances that provide accurate motion cues for flight training are not crucial to the success of a sci-fi ride, Disney and Lucas can let the simulator shake, rattle, and roll through its full six-axis range of motion. "You can accelerate or decelerate quite rapidly when you don't have to depend on motion cues for training sessions," says John Hope, manager of flight simulator development for the Boeing Company. "It doesn't have to be real, only fun." Disney plans to add Star Tours to its Florida and Tokyo facilities and to the park under construction in France.

The marriage of futuristic visuals and coordinated buffeting has your basic roller coaster beat hands down. It is, as aerospace companies have known for years, as good as being there—and at just a few dollars per passenger, a lot cheaper, too.

—Peter Potterfield

Max Karl Winkler



White Knights in Black Tie

They still have It—a lot of It. The Mercury astronauts are now in their 60s and long gone from the space program, but they still pack a room. Last February, they drew a crowd of more than 500—at $150 a head—to a dinner-dance celebrating the 25th anniversary of John Glenn's three Earth orbits.

The bash was sponsored by the Mercury Seven Foundation, which the astronauts had formed to raise scholarship money. It was a typical Washington fundraiser: a big hotel, limousines clogging the entrance, women decked in furs, men stuffed into look-alike tuxedos. Typically, the guests were stalking political VIPs, particularly Glenn, now serving his third term as Democratic senator from Ohio and thriving in his second career.

Cocktail hour was a mob scene. The astronauts stood together next to life-size 1962-vintage cutouts of themselves in spacesuits for a "photo opportunity." They all smiled on cue—by now, they're used to black-tie affairs and actually look comfortable in tuxes.

After an hour of popping flashbulbs, the crowd poured into a banquet hall so enormous it had an echo—the ideal acoustics for dance music by the U.S. Marine Band. The guests of honor engaged in a little pre-dinner banter. When asked what life was like in the Mercury years, Betty Grissom, attending for her late husband Gus, said, "I don't remember what happened yesterday, let alone 25 years ago." Deke Slayton made the obligatory joke about getting old: the second thing to go is your memory, and let's not talk about what goes first. Alan Shepard explained why he was president of the Mercury Seven Foundation: "I'm the oldest, the wisest, and the richest." Glenn summed up the evening in his all-American way: "This is like one big family reunion. I'm shooting for a golden anniversary in 2012, and you'll all be invited."

After dinner, the astronauts joined comedian Bill Dana, best known as José Jimenez, to roast Glenn. Son David, an anesthesiologist, sent videotaped greetings from California. "Like father, like son," Glenn observed, noting his own skill at putting people to sleep during the 1984 presidential campaign.

Glenn also made the keynote speech, recalling "the incredible national outpouring of pride" following his flight in *Friendship 7*. Before the handshaking, back-slapping, and dancing began, he made a lectern-thumping argument for U.S. leadership in science, technology, and space exploration. "Exploration of the unknown is the expression of America's spirit, and we'd better not let it die." "Good grief," one observer mumbled, "he's running for president again."

—Linda Billings

Pluto: The Family Eccentric

Relegated to perpetual twilight by a sun nearly four billion miles distant, Pluto plods the stygian depths of the solar system, completing one orbit about every 248 years. But the status of the outermost observed body in the sun's family has been questioned recently. Some astronomers think it may no longer qualify as a full-fledged planet.

"Well, yes and no," says Robert S. Harrington, a senior astronomer at the Naval Observatory in Washington, D.C. "Pluto's low density, estimated diameter of between 1,000 and 1,500 miles, and tipped, eccentric orbit make it unlike any other planet. There is evidence that it may be a

Susan Foster

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renegade moon of Neptune thrown into a solar orbit when a massive body passed through the outer solar system, tipping Uranus on its side and disrupting Neptune's moons. In fact, Pluto does resemble Saturn's medium-size moons."
Nonetheless, Harrington says it's still a bit premature to dethrone the god of the underworld.

"The consensus among most professional astronomers is that because Pluto circles the sun independently and can be seen at its vast distance, it still qualifies as a planet," Harrington says. "The issue really boils down to whether to consider Pluto a major planet, like Earth and Saturn, or a minor planet, like the asteroids that orbit between Mars and Jupiter. Perhaps it's in a new class altogether, unique in that it formed at the edge of the primordial gas-and-dust cloud that became the solar system, kind of like the last dollop of batter left over when you make pancakes."

Until 1781 the recognized planets included Mercury, Venus, Mars, Jupiter, and Saturn, which the ancients discovered by eye. That year William Herschel, with the aid of a telescope, found Uranus and doubled the diameter of the solar system overnight. Neptune was discovered in 1846, after calculations showed that the orbit of Uranus was being perturbed by another body. And some astronomers thought that Neptune also showed similar small tugs from yet another unknown object.

In 1930, after checking millions of star images on time-exposed photographs, Kansas farmboy and amateur astronomer Clyde Tombaugh told his superiors at Arizona's Lowell Observatory that he'd found a ninth planet. Tombaugh then went into Flagstaff to get the mail, eat dinner, and, since it was a cloudy night, watch Gary Cooper in *The Virginian.*

Originally, Pluto was thought to be the size of Mars. But as observing techniques improved and more was learned about its orbit, the planet's estimated dimensions decreased until 1978, when James Christy discovered Pluto's moon, named Charon. What was once thought to be a single body became two, with Charon estimated at half the size of Pluto. With its down-scaled size, mass, density, and relatively large satellite, questions arose over Pluto's status. Was it a planet, a double asteroid system, an escaped Neptunian moon, or something altogether new? The mystery of the remote wanderer grows ever more complex. But until more evidence is in, Pluto's planethood will remain intact.

—T.H. Callen II

A Legend Before Their Time

According to the Frye Company, a boot manufacturer in Marlborough, Massachusetts, pilots love the Frye Jet Boot. And they may have good reason. It seems that the leather shaft—the tube of the boot—is only 10 inches high and the boots are flexible and durable enough to withstand stomping on rudder pedals. They're advertised as "comfy fighter pilot boots," with a "Jet toe and heel." Their quasi-military appearance also scores points with aviators. "They're great for bus drivers, too," Frye spokeswoman Felice Katz points out.

The Frye Jet Boot story began in 1938, when John Frye, grandson of the company's founder, struck up a conversation with a rear admiral aboard a train bound for Washington, D.C. Frye was intrigued by the Navy man's footwear: pliable leather boots that extended just above the ankle.

The admiral was very fond of his boots, the story goes, but they were wearing out. He had purchased them in China, and was at wit's end because he could find nothing like them stateside. Could Frye be of any assistance?

He could. At the time jets were about as scarce as Hula Hoops, so one assumes the Frye Jet Boot was named several years after it was developed.

The boots were prized by American servicemen, particularly pilots, during World War II. Orders were placed by mail, and customers often enclosed details on where their first pair saw action. According to Frye legend, a bomber pilot wrote that he wore his Jet Boots during Jimmy Doolittle's 1942 Tokyo raid. The legend has grown, as legends often do, and today the company hints that Doolittle himself was wearing a pair of comfy Jet Boots. Chalk it up as a footnote to history.

—Tom Huntington

Update

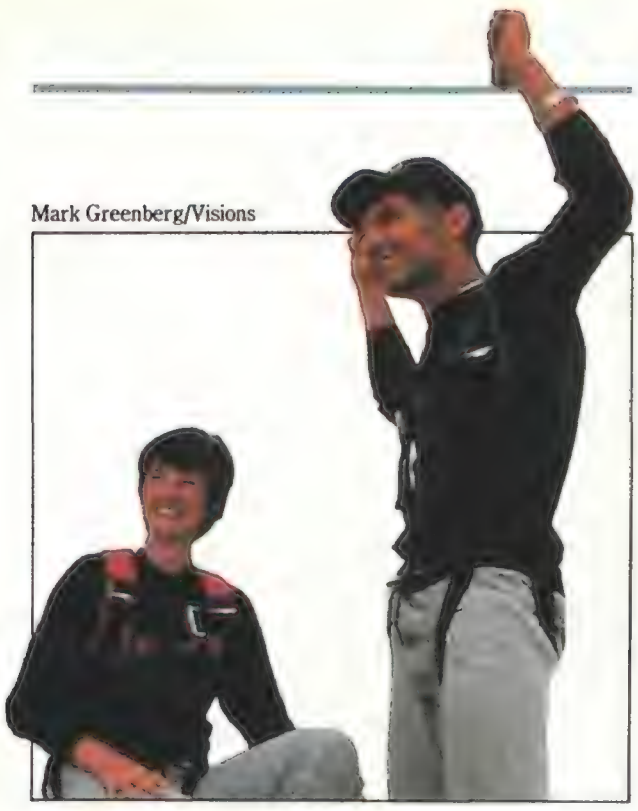
Modifications to the F-16 ("The Electric Jet," December 1986/January 1987) to increase agility and ensure domination over future aircraft are under consideration at General Dynamics. Engineers are studying airframe devices to augment lift, stability, and maneuverability. There is also talk of allowing the pilot to

George Hall

override the flight control computer when "supermaneuverability" is needed. Pilots praise the airplane's performance, but have complained that the computer-enforced restrictions hamper their combat skills. "Let the pilot say, 'Give me a little more angle of attack,' " says T.P. McAtee, a General Dynamics program manager, "knowing that he's going to lose energy. There may be a reason for him to do that."

Voyager pilots Dick Rutan and Jeana Yeager ("Voyager," October/November

Mark Greenberg/Visions



1986) will be immortalized, Hollywood-style, in a movie based more on their relationship than on their accomplishment. Heritage Entertainment president Skip Steloff foresees the plot as "an incredibly beautiful love story." Filming is scheduled to begin in 1988.

Microscopic diamonds found in meteorites may be the first identifiable interstellar material discovered on Earth ("The Curator of Cosmic Dust," April/May 1987). A team of scientists led by Edward Anders and Roy Lewis from the University of Chicago discovered in the diamonds a xenon gas found nowhere on Earth. Anders theorizes that the explosion of a large aging star could eject gases and stellar particles at velocities high enough to penetrate the diamonds, which are perhaps the oldest minerals ever examined. Further analysis could provide new information on the evolution of the stars and solar system.

Orbital Sciences Corporation ("Entrepreneurs in Space," December 1986/January 1987) recently offered to finance the purchase of a Titan 34D rocket to get the Mars Observer and OSC's booster launched in 1990. NASA, which declined the offer, has rescheduled the mission for a 1992 shuttle flight.

Provincetown-Boston Airline's DC-3s are no longer plying Florida airways ("Something Special in the Air," October/November 1986). PBA, now owned by Texas Air, is concentrating on operations in the Northeast, where the airline originated.

The *Top Gun* video became the best-selling movie in history weeks before it went on sale in March. Initial orders for the cassettes were close to two million. A Navy spokesman says the script for a sequel is due at the Pentagon any day. Paramount has not yet released any details.

—Patricia Trenner

Out of My Class

Becky Heavner

In the 32 years I've been teaching elementary school, my students' essays and examinations have taught me some fascinating facts about air and space. For instance, did you know that the first female aviator was Kitty Hawk? Or that Roger Wilco invented "the language of communications"?

One nine-year-old lamented that "the history of aviation is getting longer and harder all the time." Perhaps to compensate, some of my students have taken the fabric of that history and tailored it to their own measure. One boy cut matters down to basics. "In aviation history," he wrote, "there was first the Wright brothers, then Lindbergh, then on to now."

My students always manage to remember something about the Wrights. "Orville Wright was born in 1871, supposably on his birthday," wrote one skeptic. "The Wright brothers are two of the four fathers in aviation," wrote another student, raising further questions. A third student admired the brothers' physical skills: "When it came to mechanical things, the Wright brothers showed they had smart heads up their sleeves."

Putting it all in perspective, one youngster observed, "They both lived in the pre-me times."

Charles Lindbergh's accomplishments become equally memorable. "Charles Lindbergh was the first to fly to Paris," I once read. "He did it by the airplane method." He also had some strange powers over geometry: "A straight line is the shortest distance between two points unless you are going with Lindbergh to Paris. Things are different there."

And finally, Lindbergh seemed to have physical abilities on a par with the Wrights': "When they asked him if he would like to navigate to Paris, he rolled his eyes and flashed his teeth and said sure."

Test takers have been equally imaginative with definitions. "Spinning jennies were flying jennies that did not work," one decided. Another noted that "lift in an airplane is the same as thrust, only just the opposite." Commenting on the duties of a navigator, a lass claiming to be one of aviation's "starchest supporters" explained, "The navigator figures out the latitude and longitude. Latitude tells him where he is and longitude tells him how long he can stay there." Her best friend wrote, "Three main crewmen on a plane are the pilot, navigator, and percolator." Concluded another, "Navigators look something like people."

Some writers avoid controversial issues. "Until it is decided whether ramjets are rockets or jets, we must continue to call them ramjets," advised one. "I know what a sextant is," a student admitted, "but I would rather not say."

Other students are more courageous. One bravely tackled the controversial subject of air traffic control. "There is a group of people called the CAA. They make safety rules about airplanes. Some of their rules have advanced to the point where they are no longer understandable."

Jets are a popular topic, once you figure out what one is. "Look at a jet plane," I read once. "Does it have a propeller? Then it is not a jet plane." Moving to another paper, I discovered how a jet works: "In order to learn how jets work, I only need to blow up a balloon and let it fly into the air. Somehow this explains it to me."

"Jet planes fly faster but helicopters fly straight up and down," wrote one youngster, "so it is about six of one and one for all." "Some facts about jets are just to listen to, not to understand," according to another, who was all ears.

Rockets are another favorite subject. Much of the youthful wisdom I've collected has been devoted to an explanation of the action-reaction principle, which means that when force is exerted in one direction, the rocket travels in the other. Or as a boy named Todd put it, "Anytime there is a force pushing one way, there is another pulling the other way. Only rockets can understand this well enough to make it work for them."

"A rocket has no moving parts," another wrote. "Except itself. Straight up."

The rocket's propulsion system holds its own peculiar fascination. "Liquid fuel rockets will not go unless they have both a fuel tank and an oxider tank," explained one student. "And don't forget the match."

"Oxygen is for burning or breathing depending on whether you are rockets or people," another added.

"When the fuel gets burning, the gases rush out at the nozzle. So would anybody," a third noted sympathetically.

One lad had this encouraging report: "Only two great problems yet remain in our conquest of Mars. They are getting there and getting back." Another student looked at the project differently—"The most important thing about going to any planet or doing anything is knowing when you are there and through and stopping there and ending."

And let's not forget the unknown horrors in space—like gravity. "An orbit is the path of a body in space that is under the pull of another body," wrote one young scientist. "It's all pretty spooky."

What do children see for the future? A host of technological breakthroughs, if my students are any indication. "Even better aircraft are to be found," one wrote three years ago. "Where they are to be found is in the future tense."

"So far, planes have only been able to fly in circles of no more then 360 degrees," observed another. "This could be the next big break-through in air travel." On the other hand, that may be something Charles Lindbergh pioneered on his way to Paris.

—Mark Evans

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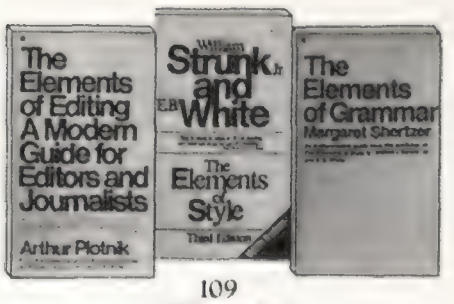

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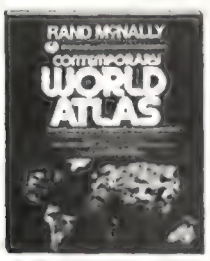

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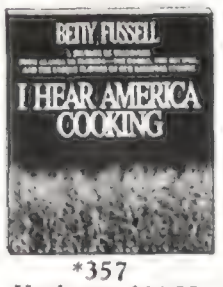

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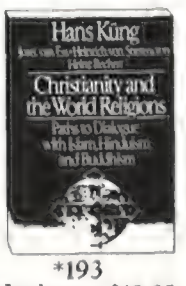

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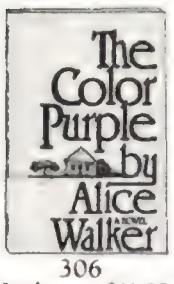

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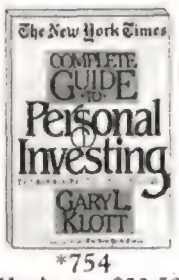

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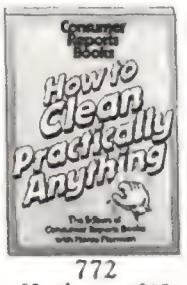

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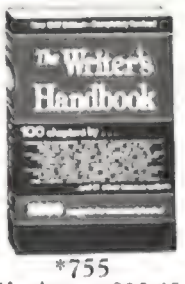

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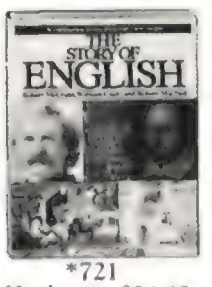

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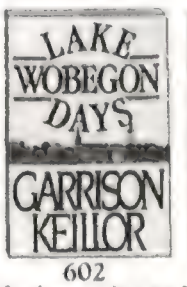

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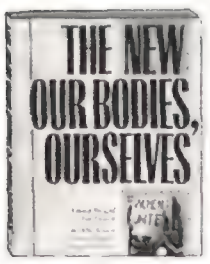

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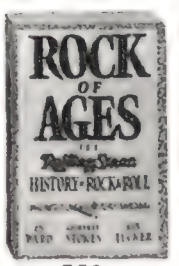

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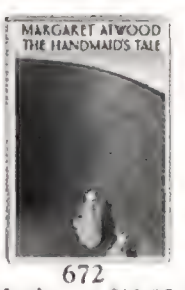

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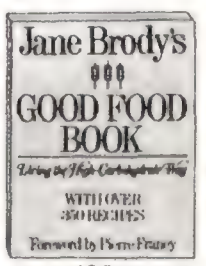

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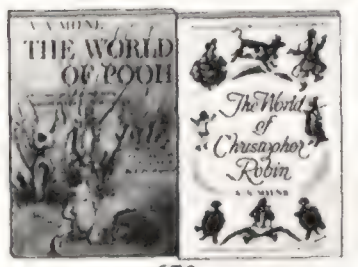

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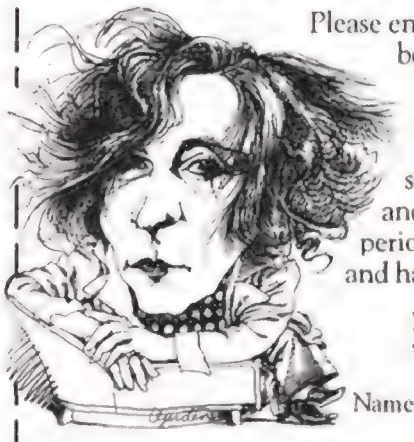

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Anniversaries . . .

Don Davis

An unidentified celestial visitor shook up Siberia in 1908.

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July 4 Chinese astronomers observe in the constellation Taurus a supernova so bright it is visible by day for three months. Still expanding some 900 years later, the gaseous remnants of this giant dying star's explosion are known as the Crab Nebula.

1687
July 6 Isaac Newton's *Philosophiae Naturalis Principia Mathematica*, which introduced the idea of gravity as a universal force, is published in England. Newton used a new method of mathematical analysis called calculus to determine the motions of planets, satellites, and comets. He also hinted at the existence of a band of comets far beyond the planets, evidence of which didn't surface until the 1950s. The *Principia* has remained the foundation of physics for 300 years, and today is considered the most influential scientific book ever written.

1908
June 30 A spectacular explosion several miles above the Siberian tundra is visible for hundreds of miles. The event downed trees for 300 square miles and produced a seismic shock, firestorm, and black rain. The Tunguska Event may have been caused by a meteorite or a piece of a comet. Usually explosions of this magnitude are caused by objects slamming into the Earth, which would leave a crater full of evidence, but because this event occurred in the atmosphere, scientists have little to work with. The debate over its origins may continue indefinitely.

1916
June 29 The first Boeing-built airplane flies, a training/sport biplane on floats conceived by William Boeing and Commander G. Conrad Westervelt, U.S. Navy. Orders for the B&W and its variations were received from the Army, Navy, and the New Zealand government.

The Boeing Company

Boeing fished for Navy contracts with his first seaplane but got only nibbles.

1927
June 4–6 Clarence Chamberlin, accompanied by Charles Levine, flies from New York to Eisleben, Germany, in Levine's Wright-Bellanca W.B.2 *Columbia*. Charles Lindbergh, who two weeks earlier flew solo to Paris, had attempted to buy the *Columbia*, but Levine demanded the right to choose the crew. Lindbergh turned to the Ryan Company in San Diego, which built him the *Spirit of St. Louis*.

NASM

Charles Levine (right) chose to compete rather than cooperate with Lindbergh.

1928
June 18 Norwegian explorer Roald Amundsen, who in 1911 became the first to reach the South Pole, disappears without a trace while searching by air for the crew of the dirigible *Italia*, which was forced down into the Arctic Ocean. Captain Umberto Nobile and five other survivors were rescued from an ice floe five days later.

1929
June 29 The Long Island Aviation Country Club opens. The first of many such clubs in the United States, it catered to wealthy recreational pilots who flew elegant biplanes in society air meets, the aerial equivalent of yachting regattas.

July 7 Transcontinental Air Transport inaugurates coast-to-coast air-rail service to

the accompaniment of a band playing "California, Here I Come." Westbound passengers traveled in Ford Tri-motors by day and trains by night to reach Los Angeles in 48 hours. One-way fares of up to $400—equivalent to $5,000 today—precluded such travel by the general public.

1933
July 1 Transcontinental & Western Air (the forerunner of TWA), unable to acquire the remarkable Boeing Model 247 airliner until United's order for 60 is filled, asks the Douglas Aircraft Company to develop a competitor. Douglas obliged with the DC-1, which was quickly followed by the DC-2 and -3, relegating the 247 to obsolescence.

1937
July 18 After the most massive air-sea rescue mission ever launched, Amelia Earhart and navigator Fred Noonan are presumed lost in the Pacific Ocean. The two were on a round-the-equator flight in a Lockheed Electra, and on July 2 had embarked on a 2,600-mile overwater leg from New Guinea to Howland Island, a two-mile-long sandbar in the South Pacific.

1938
July 17 Douglas Groce Corrigan departs Floyd Bennett Field in Brooklyn, New York (see page 34), in a nine-year-old Curtiss Robin monoplane, supposedly bound for Los Angeles. He landed 28 hours later in Dublin, Ireland, after a nonstop flight with no radio or special navigation equipment and in violation of United States and Irish flight regulations. Immediately dubbed Wrong Way Corrigan by the press, he claimed to have followed the wrong end of the compass needle.

1946
June 26 The U.S. Navy and Army Air Force officially adopt the knot and nautical mile as standard aeronautical units for speed and distance. The nautical mile, about 1.15 statute miles, is based on one minute of arc of a great circle, and a knot equals one nautical mile per hour.

1947
June 24 Kenneth Arnold, a pilot and businessman in Boise, Idaho, coins the term "flying saucer" when he reports seeing nine peculiar aircraft near Mount Rainier in Washington. Arnold was aboard his Callair single-engine airplane when he saw what looked like "saucers skipping over water" at approximately 1,700 mph. His sighting kicked off the era of UFO fascination.

1959
June 5 The Army Ballistic Missile Agency begins construction of Saturn rocket facilities at Cape Canaveral under the direction of Wernher von Braun. In November the ABMA transferred control of the program to the newly formed National Aeronautics and Space Administration, which assigned the project to its Marshall Space Flight Center in Huntsville, Alabama. The Saturn 5, which launched a total of 12 U.S. astronauts to the moon as well as the first Skylab mission, was the largest rocket the United States ever built. Its five F-1 engines consumed 534,000 gallons of liquid propellants in the two and a half minutes before first-stage burnout, at which point the rocket was passing through an altitude of 38 miles at 6,000 mph.

1961
July 1 The North American Aerospace Defense Command in Colorado begins operation of the Space Detection and Tracking System, designed to electronically catalog all man-made space objects.

1963
June 16 Valentina Tereshkova, 26, a former textile factory worker and sport parachutist, becomes the first and only woman to make a solo spaceflight. She controlled the Vostok 6 manually during the 70-hour flight and flew within three miles of fellow cosmonaut Valeriy Bykovskiy in Vostok 5. Though Tereshkova lacked the background and experience of the typical space traveler, she gained more orbital experience during her flight than all the Mercury astronauts combined.

Wide World

An Idaho pilot launched the UFO era with the first report of "flying saucers."

1966
July 12 The Northrop/NASA M2-F2 lifting-body research aircraft is launched from a B-52 at 45,000 feet for its first unpowered flight, which lasted three and a half minutes. The lifting bodies, which created lift by the shape of their fuselage, were precursors of the space shuttle in providing the solution to overheating and vehicle control during re-entry. The last lifting body flew in 1971 and was boosted by a rocket to altitudes as high as 71,500 feet.

July 18–21 During the flight of Gemini 10, Michael Collins retrieves a micrometeoroid detector from an Agena target spacecraft, demonstrating that orbiting satellites could be serviced in space. NASA public relations people exhorted the taciturn crew to be more effusive for the benefit of Earth-bound listeners.

1975
July 18 United States Apollo 18 and Soviet Soyuz 19 capsules link for 47 hours in orbit in the first international manned space mission. Different spacecraft atmospheres, systems of measurement, and languages had to be reconciled, and in preparation, the Soviet astronauts were schooled in English, and the U.S. crew learned some Russian. In orbit, they sampled each other's meals, exchanged national mementos, and separated and docked several times. It was NASA's last Apollo flight.

Sovfoto

Valentina Tereshkova, a textile mill worker, made history on her solo flight.

1976
July 28 A Lockheed SR-71 piloted by U.S. Air Force Captain Eldon W. Joersz at Beale Air Force Base, California, sets the still-standing speed record of 2,193 mph.

1978
June 22 James Christy discovers Pluto's satellite, Charon, which gave rise to doubts over Pluto's status as a planet (see "Pluto: The Family Eccentric," page 20).

1980
July 18 The Indian Space Research Organization launches its first satellite, a Rohini RS-1, in a test of the SLV-3 launch vehicle built by Vikram Sarabhai Space Center.

1981
June 19 The European Space Agency conducts its first successful developmental-phase launch of an Ariane rocket, which placed a European weather satellite and an Indian communications satellite in orbit.

. . . and Events

Through June 14
"Jupiter and Its Moons," Smithsonian Traveling Exhibition. At the lobby of Two World Trade Center, New York, NY, (212) 466-4233.

Through June 21
"Twenty-five Years of Manned Space Flight," Smithsonian Traveling Exhibition. At the Buffalo and Erie County Naval and Servicemen's Park, Buffalo, NY, (716) 847-1773.

"Early Flight: 1900–1911," Smithsonian Traveling Exhibition. At the Alabama Space and Rocket Center, Huntsville, AL, (205) 837-3400.

June 6 & 7
"Spaceflight Expo." Exhibits include Grumman Space Station Habitat Module, Space Station Command Center, Apollo Lunar Module, Project Dyna-Soar space vehicle, vintage aircraft, and NASA films. At Cradle of Aviation Museum, Mitchel Field, Garden City, NY, (516) 222-1190.

June 7
Annual Astronaut 5K Fun Run opens "Vision 87" Houston Space and Telecomm Symposium, Houston, TX. Astronauts, sports figures, and city officials will participate. (713) 225-1950.

June 8–July 31
Shuttle Camp 2001, nine week-long day sessions for children ages 8–14. Field trips to Holloman Air Force Base, White Sands Missile Range, and Sacramento Peak Observatory; workshops on the principles of flight, model rockets, and related subjects. At Space Center, Alamogordo, NM, (505) 437-2840, ext. 29.

June 11–21
Paris International Air Show. At Le Bourget Airport, Paris. International Trade Exhibition in France, (212) 869-1720.

June 26–28
International Symposium on Unidentified Aerial Phenomena. Several hundred members of the Mutual UFO Network gather for workshops on alien visits. At American University, Washington, DC. MUFON, (512) 379-9216.

June 28–August 7
Space Science and Computers summer camp. Two-, four-, and six-week residential sessions for children ages 10–16. At Champlain College, Burlington, VT, (802) 658-0800, ext. 431.

July 3–5
"America's Biggest Birthday Celebration" airshow, a feature of the sixth annual St. Louis Fair. Last year's event drew three million spectators. F-15, F/A-18, Harrier demonstrations, light-aircraft aerobatics, riverboat races, fireworks. At Gateway Arch, St. Louis, MO, (314) 367-3247.

Caroline Sheen

A Harrier jump-jet will hover over the Fourth of July bash at St. Louis.

July 4–August 2
"Jupiter and Its Moons," Smithsonian Traveling Exhibition. At New Jersey State Museum, Trenton, NJ, (609) 292-6333.

July 7 & 8
"Wings over the Ocean," "The Golden Age of Flight," and "Women in Aviation," lectures and seminars by National Air and Space Museum curators. At Lawrence Hall of Science, University of California, Berkeley, CA. Smithsonian National Associates, (202) 357-1350.

July 10–19
Second annual Sentimental Journey to Cub Haven. This year's Piper Cub fly-in celebrates the 50th anniversary of the factory's move to Lock Haven. At William T. Piper Memorial Airport, Lock Haven, PA, (717) 893-4201.

July 11 & 12
Second annual Flight Fest national model rocket competition. Open to rocketeers of all ages. At International Space Hall of Fame, Space Center, Alamogordo, NM, (505) 437-2840.

July 11–16
Joint astronomy society conference. Astronomical organizations representing approximately 25,000 members will gather for seminars, tours, parties, exhibits, banquets, and general schmoozing. At Pomona College, Claremont, CA, (415) 661-8660.

July 11–18
Battle Creek International Hot Air Balloon Championship. Approximately 200 balloonists will compete for cash prizes. The Air Force Thunderbirds will perform on opening day. At Kellogg Regional Airport, Battle Creek, MI, (616) 962-0592.

July 11–August 9
"Black Wings: The American Black in Aviation," Smithsonian Traveling Exhibition. At Pioneers' Museum, Colorado Springs, CO, (303) 578-6650.

July 12–August 9
"Twenty-five Years of Manned Space Flight," Smithsonian Traveling Exhibition. The exhibition coincides with the opening of Seattle's new Museum of Flight, which contains 30 historic aircraft and space artifacts. At Museum of Flight's Great Gallery, Seattle, WA, (206) 764-5700.

July 16–24
Space Week commemorates the Apollo 11 lunar landing of July 20, 1969. Approximately 100 cities will participate with exhibits and programs. Space Week headquarters, Houston, TX. Sandra Kruse, (713) 483-1723.

July 17 & 18
Eleventh annual Airliners International Convention. Displays, trades, and sales of airline memorabilia, from wing insignias to airsickness bags. At Adam's Mark Hotel, Indianapolis, IN. Phil Brooks, (317) 243-8259 (evenings).

July 18–22
"Case for Mars III: Strategies for Exploration," conference sponsored by the Planetary Society and the American Astronautical Society, Boulder, CO. Topics of discussion include innovative national and international programs for exploration of Mars and social and policy strategies for robotic and manned missions. At University of Colorado, Boulder, CO, (303) 494-8144.

A quarter-million ticketholders attend the annual Dayton double-header.

July 23–26
Dayton International Air Show and Trade Exposition. In addition to the stellar airshow attractions, the neighboring Wright-Patterson Air Force Base hosts an annual open house. At Dayton International Airport, Vandalia, OH, (513) 898-5901.

July 29
South Delta Aquarids meteor shower, two to three hours before sunrise. *

July 31–August 7
35th Annual Experimental Aircraft Association International Convention and Sport Aviation Exhibit. Approximately 10 percent (20,000) of the nation's private

Caroline Sheen

A wingwalker finds a cool breeze at Oshkosh, aviation's hottest event.

aircraft descend on Oshkosh for the world's largest aviation event. Intermingled in a steady stream of landings are performances by past and present military aircraft, airliners, and aerobatic teams. At Wittman Field, Oshkosh, WI, (414) 426-4800.

** For recorded information on astronomical events, call the Smithsonian Earth and Space Report, (202) 357-2000.*

Organizations wishing to have events published in Calendar should submit them at least three months in advance to Calendar, Air & Space/Smithsonian, *Gallery 211 Mezzanine, National Air and Space Museum, Washington, DC 20560. Events will be listed as space allows.*

—Patricia Trenner

Canvas Wings

The Greenwich Workshop

William Phillips' "Into the Teeth of the Tiger" portrays a conflict above China.

One of William Phillips' earliest memories is of a small yellow airplane circling above Los Angeles. This brief encounter 40 years ago, just after Phillips' first birthday, may have had significant impact, because Phillips has since become one of the nation's premier aviation artists. Although he has virtually no formal training, his paintings of airplanes in flight hang throughout the world, in museums and private collections from the Pentagon to the Royal Saudi Air Force headquarters. Starting in June, a retrospective of his work will be featured in the Flight in the Arts Gallery of the National Air and Space Museum. Titled "Into the Sunlit Splendor," the show will run through June 1988.

Phillips didn't always intend to be an artist. After a tour as an Air Force policeman in Vietnam, where he whiled away his free time sketching airplanes, he studied law enforcement in Oregon. He probably would have continued on to law school, but a chance encounter during his senior year changed his plans.

In the studio of his Ashland, Oregon home, Phillips recalls the day his art career took wing. He was hanging some of his paintings in a restaurant when a diner approached him, interested in buying the four oils. He offered only $25 per canvas, but it was enough to shoot down Phillips' plans for a law career. "I had always wanted to be an artist," he says. "Law was secondary, that was something you *had* to do. I walked out of there and thought to myself, 'Darn it, this *is* possible.' "

So Phillips joined the Ashland Fire Department, a job that left him enough time to paint. Vowing not to sell any more work until he had gained confidence in his style, Phillips began studying art textbooks and the work of artists he admired, particularly Hudson River school landscapes. After three years of perfecting his craft, he decided it was time to start selling.

But Phillips didn't want to sell his work as commercial illustration. He saw his aviation paintings as fine art: "I figured, Why the heck not? You've got marine art. What's marine art? It's nothing but ships. But a lot of marine art is now considered fine art."

The trick was convincing gallery owners. "When I started approaching art galleries with the idea of aviation art as fine art, they weren't hearing it," Phillips recalls. "The standard answer I got from most galleries was 'What else can you do?' "

Wildlife art was popular at the time, so in 1975 Phillips began selling waterfowl paintings. He also joined the Air Force Art Academy, a program in which he visited bases across the country, did paintings of various aircraft, and donated the finished

Christopher Briscoe

Phillips would like to see aviation paintings accepted as fine art.

works to the Air Force Academy in Colorado Springs.

His birds interested galleries more than his airplanes until he brought samples of his aviation art to a one-man show and received on-the-spot commissions. Things picked up more in 1978, when Phillips began selling his work through Virginia Bader, owner of a gallery in Alexandria, Virginia, devoted exclusively to aviation art. Phillips contacted other interested gallery owners, and by 1980 he was selling enough work to quit his job at the fire department.

Despite his success, Phillips has a realistic view of his audience. "I paint primarily for the aviation enthusiast," he says. "The formal art critics, unless they're critiquing just the composition of a painting, are still a little bit naive about how they perceive what aviation art is and what the artist is trying to get across."

It's an attitude Phillips would like to change. "Many times anywhere from 50 to 60 percent of the background I have in a painting involves a very dramatic land- or cloudscape," he says. "The airplane is very much part of the composition, but the composition has to hold up as a landscape first. There are other philosophies in aviation art that hold that the airplane has to be the first priority, but my philosophy is that it doesn't."

Phillips begins most of his major works as abstract sketches in order to plan the desired flow and balance. He often depicts his subject aircraft from the rear, the wingman's point of view and also the best look into the painting's action.

Two of Phillips' favorite paintings are "Thunder in the Canyon," which shows the U.S. Air Force Thunderbirds swooping through the Grand Canyon in the late afternoon, and "Inbound: The Giant Begins to Stir," which captures Jimmy Doolittle's B-25 approaching the Japanese coast for his bombing raid on Tokyo. "Into the Teeth of the Tiger" depicts P-40 pilot Don Lopez's too-close encounter with a Nakajima "Oscar" over China. (Lopez today is the deputy director of the Museum.) Another favorite, "Welcome Home, Yank," often elicits a strong response. The portrayal of a British Spitfire escorting an American B-24 Liberator—one engine dead, another trailing smoke—to the White Cliffs of Dover awakens vivid memories in World War II veterans.

Phillips researches his work thoroughly by talking with people closely acquainted with the airplanes he paints. He also has an extensive aviation library and keeps up on the latest aviation news through memberships in several societies.

Although the artist counts "Hellfire Corner," which depicts a conflict during the Battle of Britain, among his best paintings, it demonstrates that even meticulous research won't prevent an error. Phillips created a spirited rendering, but he later learned that no German pilot during the second world war ever painted the tips of his propellers yellow.

Phillips is interested in far more than the placement of rivets and the details of an airplane's insignia. He strives to show how an aircraft fits into its environment, and how it actually feels to fly.

To that end, Phillips flies as an observer in military aircraft whenever possible, and has flown in the F-15, F-106, F-4, and T-38, among others. His flights, often arranged through the Air Force Art Academy, have taken him from the interior of the Mount St. Helens crater shortly after its eruption to a typhoon off the coast of Guam. He documents these trips with photos as well as movie and video footage that he studies later. Although he obtained his student license and soloed in 1973, the expense of flying himself has been too steep. He hopes to take it up again soon.

Although the Museum show offers a good overview of Phillips' work so far, there is much more he wants to do. "I really want to experiment with color and its possibilities," he says. "There's so much more to aviation that I want to try, as far as showing the airplane in the environment of that great amount of space and the light that's involved. I'd like to show even more movement in the paintings."

He also has ambitions for aviation art as a whole. "I am going to be throwing my efforts behind a movement to try to get aviation art accepted into the 'fine art' community," he says. "There's no reason,

Spitfire meets Messerschmitt at the Battle of Britain's "Hellfire Corner."

The Greenwich Workshop

other than a reluctance in a very conservative art establishment, that it can't move in that direction. I see a very bright future for aviation art."

—*Michael Berry*

Bus Stop

A museum is not a lending library or a warehouse, but occasionally items from the Museum are loaned or brought out of retirement. Last winter, part of an exhibit at the Museum took a busman's holiday in California, temporarily re-entering active service with the National Aeronautics and Space Administration.

NASA's Jet Propulsion Laboratory in Pasadena is building *Magellan*, a spacecraft that will take off in 1989 on a mission to map the surface of Venus. But after last year's *Challenger* accident, JPL designers had to do some rapid rethinking. For safety reasons NASA dropped the Shuttle-Centaur, a liquid-fuel upper stage that would have propelled *Magellan* out of Earth orbit after liftoff in a shuttle. *Magellan*'s new design calls for a solid-fuel inertial upper stage, and that means a redesign of the spacecraft to accommodate the new booster.

By last fall project managers realized they needed to test a new *Magellan* structural model. But time and money were running short, so project manager John Gerpheide asked Museum officials if he could borrow part of the Voyager spacecraft on display in the Museum's Exploring the Planets Gallery.

Magellan is "a Cinderella spacecraft," says program manager Rod Mills, meaning that it was constructed from parts left over from other space projects, including Voyager. JPL wanted a Voyager bus, the central platform that carries computers and batteries and serves as a base for antennas and other attachments. The Museum's bus is the only existing spare, and the machine tooling for making new buses has been destroyed.

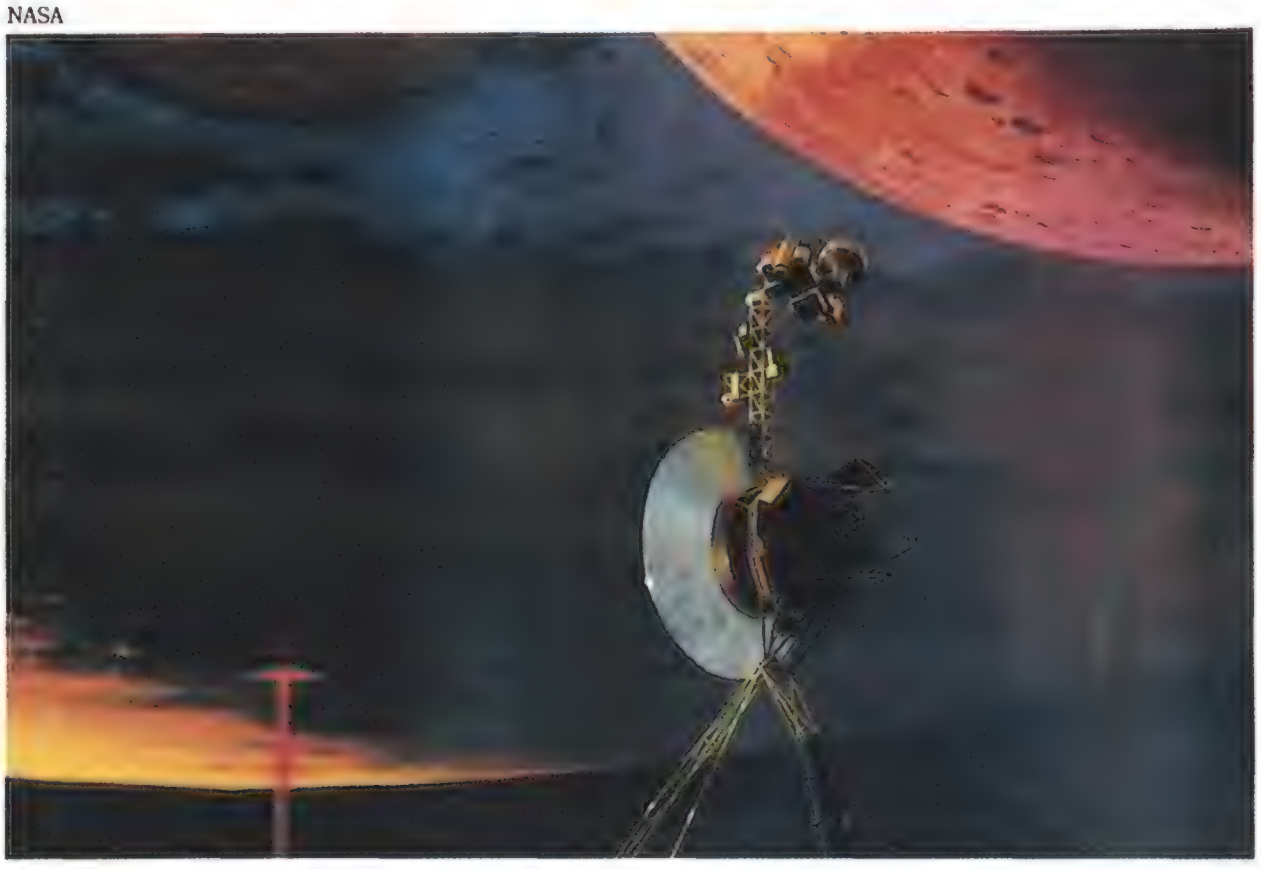
Museum officials eventually agreed to loan the bus—under certain conditions. The Museum's Voyager combines actual components with some made for the display, so JPL will compile an inventory identifying the parts' origins. To ensure that the display Voyager's appearance would not be altered, JPL replaced the borrowed bus with a facsimile. Finally, JPL promised the Museum surplus *Magellan* hardware.

Last January a handful of JPL technicians left California for Washington to catch their bus. A crew from the Museum's Garber Facility helped out with the delicate job, which took a week to complete.

In the computer simulations seen on television, the Voyager craft look like insects, but in fact they're quite large. Voyager's white dish antenna is 12 feet across, its large magnetometer boom is 43 feet long, two boomlets carrying more equipment measure about 15 feet long, and two whip antennas are 33 feet long. With all its trimmings the spacecraft weighs well over 1,000 pounds. Removing the bus from such a piece of equipment was not an easy task. The body of the spacecraft had to be

The Voyagers will never return to Earth, but they left spare parts for Magellan.

NASA



detached from its booms and antennas and then lowered from its perch across the ceiling of the gallery. The moving team next peeled back a thermal blanket, removed the bus (which looks like a 10-sided box), installed the facsimile, draped the blanket over it, and cranked the spacecraft back into place.

Then the bus was off to winter in California. JPL will make a few modifications and then use it for four months of testing later this year. Museum officials have agreed to let JPL keep the bus until *Magellan* finishes its mission in 1991.

The loan has saved the *Magellan* project time and money, so NASA is happy. According to JPL project representative Joe Plamondon, "The saving is hard to pin down, but it's probably in the neighborhood of a half a million dollars," as well as many months of work.

Museum officials will get their bus back along with an inventory of Voyager parts and an assortment of *Magellan* artifacts, so they're also pleased. It was a deal made in the true spirit of compromise, the way things are usually done just up the street from the Museum—in the Capitol.

—Linda Billings

Bookends

At Maryland's Andrews Air Force Base last March, the U.S. Navy marked the end of an era when it retired its last F-8 Crusader. The airplane, an RF-8G photo reconnaissance version of the jet fighter, entered retirement as the latest addition to the Museum.

Among the airplane's NASM brethren is the very first Crusader, the XF8U-1 prototype. The older aircraft happened to be at Andrews during its younger sibling's retirement celebration, getting a slight touch-up before being loaned to the Seattle Museum of Flight.

The F-8, a high-wing, single-seat fighter, was created as an entry for a Navy competition to design a new carrier-based fighter. Chance Vought Aircraft's design, with its narrow fuselage, swept wings, and gaping front air intake, fit the bill perfectly. It may not have been beautiful, but the Crusader was fast, with a top speed of Mach 1.5. Equally important, a revolutionary variable-incidence wing design enabled it to fly slowly enough to land on a carrier. By the time the F-8 production lines shut down in 1965, they had turned out over 1,200 airplanes, which served 36 Navy and Marine squadrons.

The XF8U-1 prototype first took to the skies over Edwards Air Force Base in California on March 25, 1958, under the control of Chance Vought's chief test pilot, John Konrad. The first flight was an auspicious debut: the airplane exceeded Mach 1, becoming the first Navy fighter to fly faster than sound in level flight. Following its successful test program, the prototype served mainly as a chase airplane. When it was given to the Smithsonian in 1960, it had logged over 500 hours in the air.

The Museum's new RF-8G Crusader flew with cameras instead of guns. It has accumulated the most flight time of any Crusader—7,400 hours—and it is a veteran of several tours in Southeast Asia. Following its decommissioning ceremony, the airplane was flown to nearby Dulles airport for temporary storage and a quiet retirement. It did not receive a gold watch.

—Tom Huntington

Museum Calendar

Except where noted, no tickets or reservations are required. Call Smithsonian Information at (202) 357-2700 for details.

Summer Hours. Until Labor Day the Museum is open daily from 10 a.m. to 9 p.m.

Summer Concert Series. Music by U.S. armed services bands, selected weekdays on the west terrace, noon to 1 p.m. **Spectrum**—Air Force rock, June 3, July 1 and 15. **Airmen of Note**—Air Force jazz band, June 17 and July 22. **Commodores**—Navy jazz, Fridays in June, July 3, 24, and 31. **Country Current**—Navy country, Thursdays in June and July.

June 6 Monthly Sky Lecture: "The Great Equatorial," on the 26-inch telescope at the Old Naval Observatory. Jan Herman, historian at the Naval Medical Command. Albert Einstein Planetarium, 9:30 a.m.

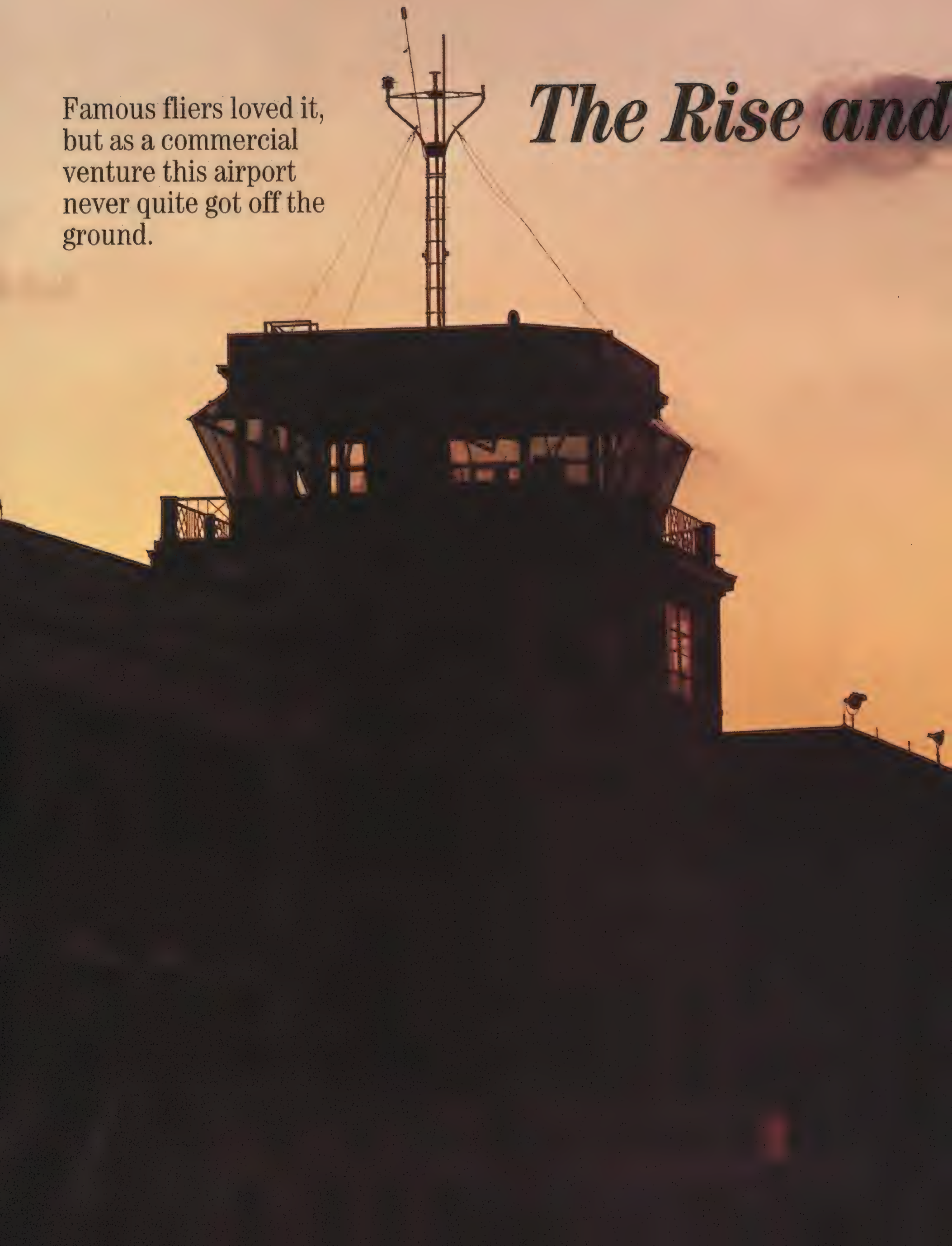
June 17 Exploring Space Lecture: "Star Formation and Stellar Demise." Harry Shipman, professor of physics, University of Delaware. Albert Einstein Planetarium, 7:30 p.m.

June 19 Exhibit Opening: "Into the Sunlit Splendor," 40 oil paintings by William Phillips. Gallery 211.

July 11 Monthly Sky Lecture: "A Hundred Thousand Million Suns," on the summer Milky Way. Geoffrey Chester, planetarium production coordinator, NASM. Albert Einstein Planetarium, 9:30 a.m.

The Rise and

Famous fliers loved it, but as a commercial venture this airport never quite got off the ground.



Fall of Floyd Bennett Field

by Marianne Cannava Scarino

Ask New Yorkers about Floyd Bennett Field and you'll probably get a lot of blank looks. Some might tell you it's a national park, which it is. Others might tell you it's an airport, which it was.

Its aviation heritage is still apparent. The green-glass flight tower looms over the runways, but now they're choked with weeds. The hangars still stand, but they are huge, eerie, rotting structures, empty except for pigeons cooing in the rafters. The few remaining doors rattle on rusted hinges, and the sun peeks through holes in the roofs.

This is airfield as ghost town, but visitors can still hear the buzz and hum of propellers. It's no hallucination: weekend hobbyists of the Pennsylvania Avenue Radio Control Society use one of the runways to fly model airplanes. Some are scaled-down replicas of machines that used the same runways more than 40 years ago.

It was in 1925 that New York City officials, stung by the success of New Jersey's Newark Airport, decided to construct the city's first municipal airfield. They commissioned aviator Clarence D. Chamberlin to choose the site. He recommended Barren Island—a 387-acre marsh with 33 small islands that could be connected with landfill—because of the area's mild weather and complete lack of obstructions.

Floyd Bennett Field's flight tower still stands, but today the only airplanes it watches over are models.

Black-and-white photographs by Rudy Arnold

Color photographs by Ken Kerbs

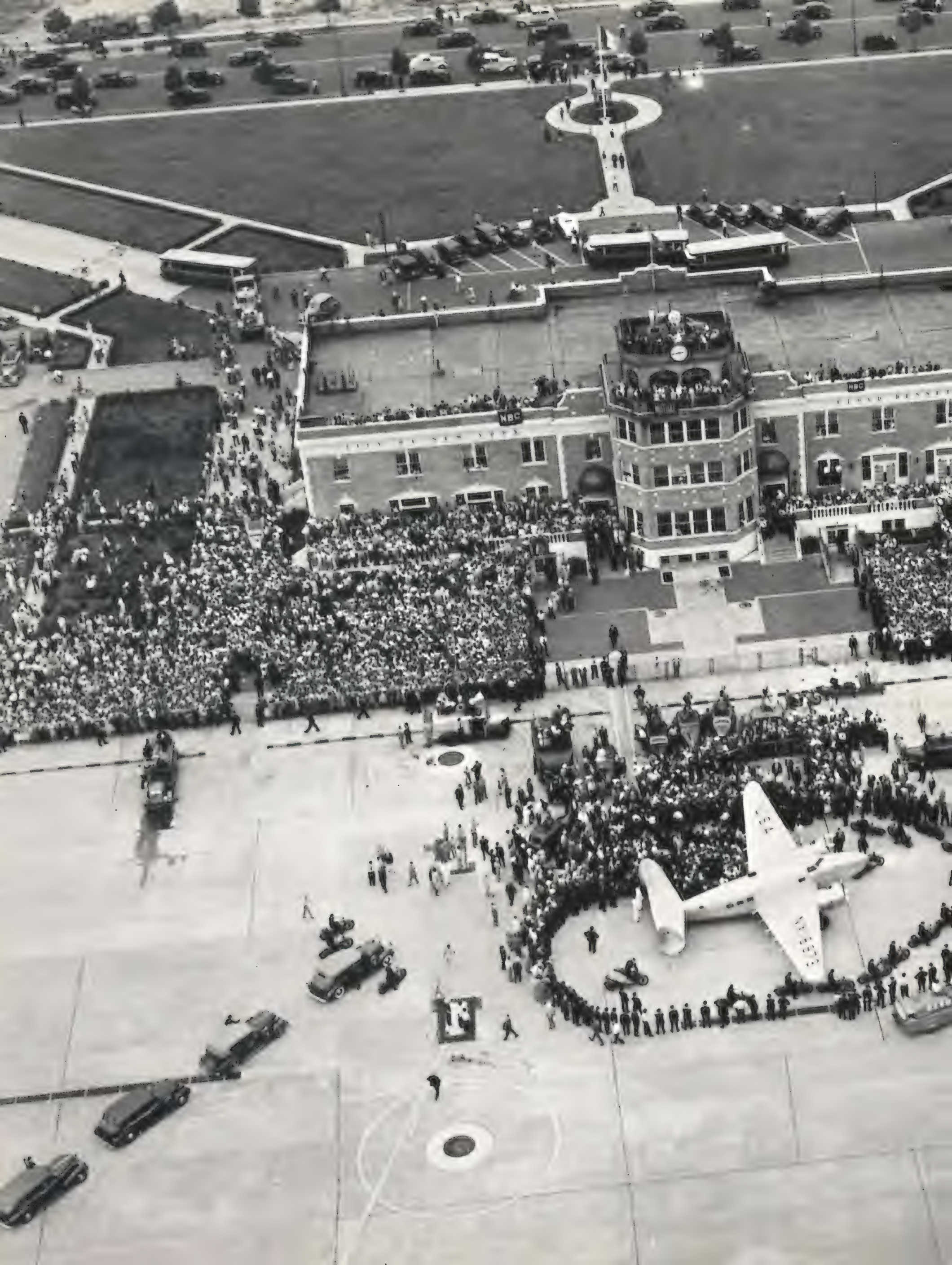
There was no debate about what to name the field. Floyd Bennett, though born in Warrensburg, New York, had lived in Brooklyn and had been New York's favorite aviator. A former World War I flight instructor, Bennett served as one of the pilots who accompanied Commander Richard E. Byrd on the 1925 MacMillan Polar Expedition to the Arctic. Bennett teamed up with Byrd again a year later to copilot the Fokker trimotor *Josephine Ford* on the first flight over the North Pole. He followed these accomplishments with a daring rescue attempt in Labrador, Canada, in 1928, which ultimately cost him his life.

Choosing a name for the airport proved a lot easier than persuading the U.S. Postal Service to designate the field an official airmail terminus—an appointment crucial for financial survival. City officials spared no effort to get the designation. A seaplane base was constructed on the southern waterfront, and sections of Flatbush Avenue were rerouted

There's more plain than plane to be found at the field today. Children's groups looking for wilderness use it for camping.

Louis Blériot (mid-ladder), the first person to fly the English Channel, visited the airfield in 1935.

The size of the airplanes has changed since the field's glory days, but youngsters continue to be fascinated by flight.


NBC
NBC

The airport's administration building was a welcome sight to aviators finishing grueling cross-country and transatlantic flights.

In 1938 Howard Hughes circled the world in three days. Thousands watched him land his Lockheed Electra at the airfield to set a world record.

Best remembered today as an eccentric billionaire, Howard Hughes was also an accomplished aviator. His well-planned round-the-world flight halved Wiley Post's time.

and widened to create a more direct route for trucking mail into Manhattan.

The effort resulted in the most advanced airport of its day. At the time of its dedication in 1931, Floyd Bennett Field boasted state-of-the-art lighting and maintenance facilities, and its reinforced-concrete runways were far superior to the gravel ones used by most municipal airports. Although the facilities were better than Newark's, it was still quicker to move mail into the city from the New Jersey field. Floyd Bennett never received an airmail designation.

The modern facilities and the airport's location at the southernmost tip of Brooklyn, hard by the eastern seacoast, did attract a number of daredevil pilots. Between 1931 and 1939, Floyd Bennett Field accommodated the landings and takeoffs of transatlantic, transcontinental, around-the-world, and record-breaking flights by the likes of Wiley Post, Howard Hughes, Amelia Earhart, Roscoe Turner, Laura Ingalls, Jimmy Doolittle, and Jacqueline Cochran. Douglas Corrigan's "wrong way" flight from Floyd Bennett to Ireland provided some sorely needed chuckles in the Depression year 1938.

But the lack of airmail business ultimately doomed the airfield to commercial failure. In 1941 Floyd Bennett was sold to the Navy,

Roscoe Turner flew from the field in 1933 to win the Bendix race and set a cross-country record. A flamboyant personality, he often flew with a pet lion.

Jimmy Doolittle flew his Seversky DS for the Shell Oil Company. In 1935 he used an American Airlines airplane to set a transcontinental speed record for passenger transports.

The runway, however worn, is the real thing, but model airplane enthusiast Paul Campisi's scaled-down Piper gives new meaning to the word "cub."

Amelia Earhart took off from New York in her Lockheed Electra at the start of the 1936 Bendix race. A year later she disappeared over the Pacific in the same "flying laboratory."


NC86391

The historic airport is part of a national park, where members of the Jamaica Bay Riding Academy find wide-open solitude.

In 1933 one-eyed Wiley Post took off from the field in his Lockheed Vega Winnie Mae *to make the first solo flight around the globe. Fifty thousand people greeted his return.*

The crew of a Martin flying boat found the seaplane facilities useful. But not even water access helped Floyd Bennett Field score an airmail contract.

which commissioned it as the New York Naval Air Station. Under the new owners, the field became one of the busiest airports in the country. The roar of the engines subsided at the end of World War II, though it rose again during the Korean and Vietnam Wars, when the Navy and Marine Corps used the airport as a base for their air reserve squadrons. After the field was decommissioned in 1971, the Navy turned the land over to the Department of the Interior for inclusion in the Gateway National Recreation Area, which includes nearby Jamaica Bay, Breezy Point, coastal sections of Staten Island, and Sandy Hook, New Jersey.

Today Floyd Bennett Field hosts an odd mix of activities. Down the road from the condemned remains of the World War II barracks and officers' club, the New York Audubon Society maintains shelters for a rare (in New York City, at least) species of owl. Across the runway from the flight tower a sign admonishes visitors not to disturb the birds nesting in the grasses. Past the nests lies a field where children's groups can camp overnight in a "wilderness" outing. Summer means outdoor concerts; fall features astronomy nights.

Although both Coast Guard and New York City Police helicopter facilities evoke Floyd Bennett Field's aviation past, the place is usually very quiet. Sea gulls crowd the runways now. Facing into the wind, they seem to caricature a squadron of World War II fighters ready for takeoff.

Much has changed since its glory days, but Floyd Bennett Field still offers the best uninterrupted view of sky in New York City. And that's how it should be. ✈

The aviators and their airplanes are long gone, but the empty hangars remain as silent memorials.

Coast Guard vice admiral and aviator D.C. Thompson and an HH-65A Dolphin helicopter help preserve the field's aviation heritage.

Motorcycle classes are held on the weekends, the noise of the engines quickly lost in the wind.

Two years ago Steve Hawley, Bruce McCandless, and Kathy Sullivan thought they knew what they'd be doing the week of August 8, 1986: they were going to be mission specialists on space shuttle flight 61-J. On this mission, the orbiter *Atlantis* would launch the Hubble Space Telescope into orbit about 370 miles above Earth. From this vantage point, with a view unhindered by our planet's atmosphere, the telescope would see as no telescope had seen before.

In late 1985, in a routine reshuffling of schedules, the National Aeronautics and Space Administration postponed the launch from August to October 1986.

But the telescope is still on the ground, and so are the astronauts, and so, of course, is the shuttle.

In January 1986 *Challenger* exploded. In October NASA announced its timetable for resuming shuttle flights, which were suspended after the accident. NASA now plans to launch the telescope aboard *Atlantis* in November 1988. (The telescope is too big and too heavy to be carried by any launcher other than the shuttle. And as the lightest of NASA's orbiters, *Atlantis* is the best suited for lifting the massive observatory into space.)

If this schedule does not slip—and that's a big if, considering all the changes NASA must make in its shuttle fleet before flights resume—the Hubble Space Telescope will arrive in space more than two years later than planned. But no matter when the launch occurs, the delay has already complicated the lives of the astronauts who have prepared to deliver the telescope into orbit. It has also had a significant impact on the hundreds of people involved in the telescope's construction, testing, and eventual operation, as well as the thousands of astronomers who plan to use the telescope and the data it will produce to expand our understanding of the universe.

Among those most affected by the delay, reactions range from "We thank God that we have this extra time" to "These very long delays have been very damaging." And often this range is covered by a single person; both of these statements, for example, were made by Riccardo Giacconi, director of the Space Telescope Science Institute in Baltimore, Maryland.

NASA is on the verge of announcing a crew for the rescheduled telescope launch, now designated flight 30. It won't be surprising if most of the members of the original 61-J team make it onto flight 30: all five members of the first crew—rounded out by commander John Young and pilot Charles Bolden—have flown on the shuttle before, and all have made specific preparations for the mission. McCandless and Sullivan's skills are especially relevant to the telescope mission. McCandless pioneered the use of the manned maneuvering unit (MMU), the jet-propelled backpack that allows astronauts to move freely in space. Sullivan was the first American woman to engage in extravehicular activity—that's EVA to NASA, spacewalk to the rest of us.

Indeed, Hawley, McCandless, and Sullivan have rehearsed deploying the telescope so many times that they are almost assured assignments to flight 30. Hawley will operate the shuttle's robot arm, which will pluck the telescope from the cargo bay and place it in orbit. If something goes wrong that has to be fixed by an astronaut in space, McCandless and Sullivan will be ready to go.

Ideally, the deployment mission will follow this course: After liftoff from Kennedy Space Center in Florida, the crew will spend about 29 hours making routine equipment checks and adapting to weightlessness. Once everything checks out, Hawley will man the robot arm controls. Floating inside the orbiter at the rear of the flight deck, he'll direct the arm to reach into the cargo bay and grasp the telescope. At this point, the front end of the telescope will be pointing toward the front end of the orbiter. Hawley will keep tabs on his work by watching two monitors hooked up to six cameras—one in each corner of the cargo bay, one on the robot arm's elbow joint, and one on its wrist joint. Hawley says that during mock deployments at Johnson Space Center in Houston, "one of the main things I worked on . . . was deciding which camera I'd be using at a certain time."

Once he has grabbed the telescope, Hawley will flip a switch to turn on its internal battery pack, which will generate power until the telescope's solar arrays deploy in space, and turn off its electrical connection to the orbiter. Then he'll flip another switch to open latches securing the spacecraft in the bay and, using the robot arm, lift the telescope up and out into open space.

Next comes a maneuver that Hawley calls "very tricky." In order to shield

Spacesuited astronauts plunge into preparations for delivering a unique observatory into orbit.

by Katie Janssen

The Hubble Space Telescope is on hold. For some, it's agony—but for others, a much-needed reprieve.

Illustrations by Pierre Mion

GROUNDED

the telescope's ultrasensitive optics from the light, heat, and other disturbances created by the orbiter, he'll have to flip the telescope end over end through 180 degrees so that its front end points away from the orbiter. In practice sessions, he says, he's achieved "a comfortable amount of clearance between the telescope and the orbiter. When I say comfortable, I mean a few feet or so."

The telescope's solar arrays and high-gain communications antennas will then unfold on command. All the while, ground controllers at NASA's Goddard Space Flight Center in Greenbelt, Maryland, will be checking the telescope's vital signs via satellite. Once they deem them satisfactory, they will activate the telescope's pointing control system, which will give the telescope its orientation. Finally, Hawley will release the telescope into orbit.

For the next 48 hours, the orbiter will remain within 50 or 60 miles of the telescope as Goddard's ground crew continues checking its condition. One day after the telescope is released, the ground crew will beam up a signal to open the aperture door, the big flap at the front of the telescope that will have protected its delicate viewing apparatus during launch and deployment.

If all does not go smoothly in space, the mission specialists aboard *Atlantis* will be ready to troubleshoot. Hawley, McCandless, and Sullivan have planned and practiced procedures to handle a number of hitches: for instance, the power link between orbiter and telescope may fail to shut off, the solar arrays or antennas may not deploy, or the aperture door may not open. A spacesuited astronaut or two working outside the shuttle may be in the best position to solve such problems. As Sullivan explains, "Bruce McCandless and I will be about halfway through our preparations for EVA" while Hawley works through his deployment sequence. "We won't be in our spacesuits or sitting in the airlock or anything, but we will be wearing our cooling suits in preparation for putting on our spacesuits, and we will have already started pre-breathing exercises. We will need only about one and a half or two hours to get out."

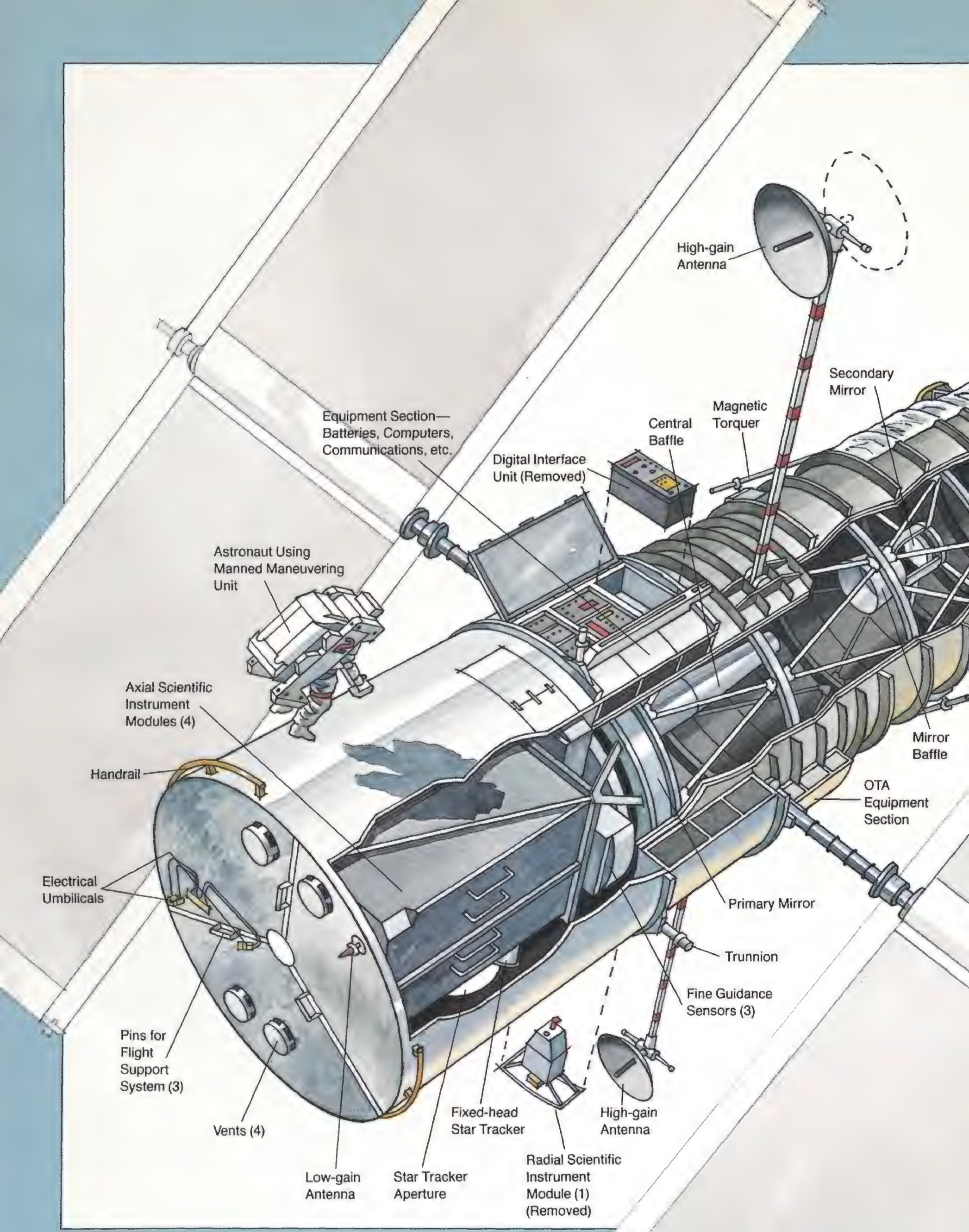
To prepare for their possible duties in space, Sullivan and McCandless have put in hundreds of hours underwater. At NASA's Marshall Space Flight Center in Huntsville, Alabama, and Johnson Space Center, spacesuited astronauts work with shuttle and spacecraft models in huge neutral-buoyancy tanks that come as close to simulating weightlessness as anything on Earth. McCandless and Sullivan have used their tank time to rehearse deployment and develop maintenance and repair procedures.

The telescope is designed to last in space for at least 15 years, but certain parts—batteries, for instance—will

Underwater, Bruce McCandless tries out a tool of his trade on a mockup of the Hubble Space Telescope.

Flip and Debra Schulke

The telescope has a heart of glass—its primary mirror comes about as close to perfection as any in the world.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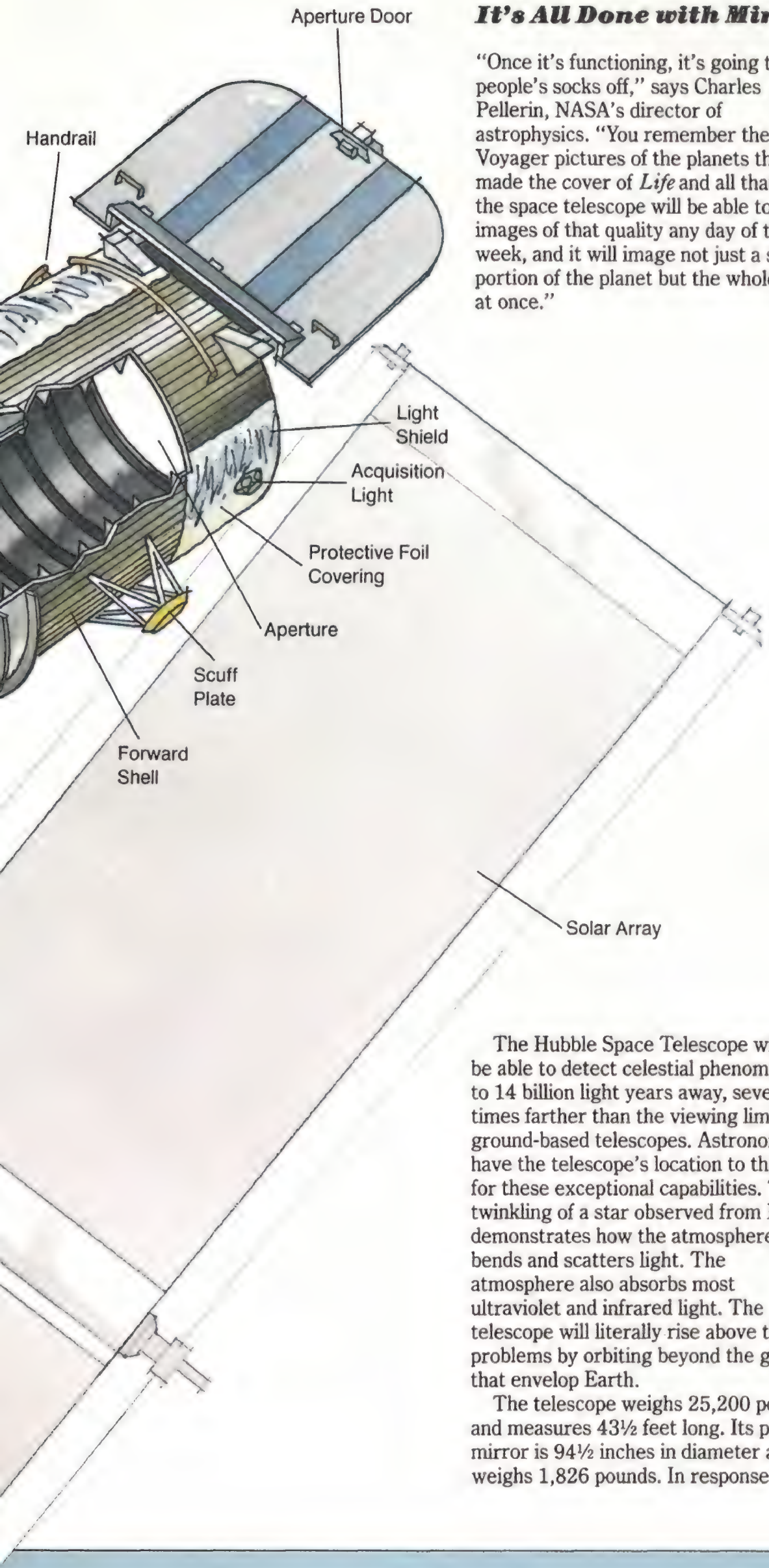


It's All Done with Mirrors

"Once it's functioning, it's going to blow people's socks off," says Charles Pellerin, NASA's director of astrophysics. "You remember the Voyager pictures of the planets that made the cover of *Life* and all that? Well, the space telescope will be able to get images of that quality any day of the week, and it will image not just a small portion of the planet but the whole thing at once."

The Hubble Space Telescope will also be able to detect celestial phenomena up to 14 billion light years away, seven times farther than the viewing limit of ground-based telescopes. Astronomers have the telescope's location to thank for these exceptional capabilities. The twinkling of a star observed from Earth demonstrates how the atmosphere bends and scatters light. The atmosphere also absorbs most ultraviolet and infrared light. The telescope will literally rise above these problems by orbiting beyond the gases that envelop Earth.

The telescope weighs 25,200 pounds and measures 43½ feet long. Its primary mirror is 94½ inches in diameter and weighs 1,826 pounds. In response to signals from ground controllers, the telescope's fine guidance sensors will lock onto a segment of space by comparing the pattern of objects it detects to a map of guide stars. When light enters the telescope, it will first strike the primary mirror, which will concentrate and reflect it onto the 12-inch secondary mirror. This mirror will direct the light through a hole in the center of the primary mirror and onto the focal plane, where the image forms. Other mirrors will channel the image to scientific instruments mounted behind the primary mirror.

Each of the telescope's five instruments is specialized, but some of their functions overlap. The wide-field/planetary camera will search for planets around nearby stars and study the atmospheres of planets in our solar system. The faint-object camera will also hunt for planets and for clumps of dust and gas falling into proto-stars. The high-resolution spectrograph, sensitive only to ultraviolet light, will scan interstellar space for trace materials that could help explain how stars evolve. The faint-object spectrograph will analyze the chemical makeup of galaxies and other celestial objects. And the high-speed photometer will examine objects of fluctuating brightness such as X-ray binary stars.

No astronomer will ever peer through the space telescope. Instead, the telescope will convert the light it collects into electronic signals. Each bit of light, or photon, collected by the wide-field/planetary camera will strike one of the 640,000 elements in an array of charge-coupled devices, or CCDs. Each CCD on the array, which measures less than a half-inch square, will build up a charge proportional to the number of photons that have hit it. As often as several times a second, the charge on each CCD will be measured and combined with the location of the CCD in a digitized code.

The other instruments will use photo-multipliers, which cause photons to create a cascade of electrons. The electrons strike plates at the rear of the instruments, which similarly count and map the intensity and location of light sources. This digital information will be relayed to Earth by satellite. Ground-based scientists will use computers to reconvert the coded data to visual images.

—Katie Janssen

have much shorter lifetimes. And some of the observatory's scientific instruments will become outdated long before the telescope wears out. To give shuttle-based astronauts easy access to hardware that needs to be fixed or replaced, the telescope was built as an aggregate of modules. Instruments were installed in massive drawers mounted on sliding tracks. There will be scheduled maintenance missions every two and a half years or so, according to McCandless.

Since 1980, engineers and technicians at Marshall have been using telescope mockups to test orbital servicing techniques, and McCandless and Sullivan have helped out. NASA used scale models for preliminary tests in 1979 and 1980, "but now we're working with a more accurate model, and we're able to use actual EVA tools. We're reviewing, repeating, and updating earlier work," Sullivan says. McCandless puts it more plainly: "We have become intimately familiar with the systems."

The space telescope itself is waiting out the launch delays in a 520-cubic-foot room at Lockheed Missiles & Space Company in Sunnyvale, California. The "clean room" has air filters that screen out particles larger than half a micron (1/2,000 of a millimeter) and huge fans that change the air every 90 seconds. NASA hired Lockheed to assemble and test the spacecraft and Perkin-Elmer in Danbury, Connecticut, to build the optical telescope assembly—the primary and secondary mirrors and the structure that houses them. Sullivan and McCandless were on hand at certain critical stages in the telescope's assembly. "Over the last two years or so, we did this work episodically—every couple of months, we did another set of tank runs or went out to Lockheed for a couple of days," Sullivan says.

But these visits are less frequent now. Since late March the telescope has been in a "nontest period"—downtime, though Lockheed doesn't like to call it that. Company officials are quick to point out that technicians are closely monitoring the telescope and its ultraclean environment during this period, scheduled to last for six months but subject, of course, to extension. In any case, well before the telescope went into storage, Lockheed had cut its telescope workforce from 500 people working three shifts seven days a week at the time of the *Challenger* explosion to 200 working one shift five days a week.

Lockheed isn't the only organization that's had to cope with the launch holdup. NASA headquarters in Washington, D.C., Marshall Space Flight Center, Goddard Space Flight Center, and the Space Telescope Science Institute all have detailed work plans and schedules tied to the telescope launch.

As NASA's lead center for the telescope project, Marshall has had overall responsibility for development and management. During the telescope's first 30 to 60 days in space, the Marshall center will direct the on-orbit instrument verification and checkout. (Like New Yorkers who no longer stand in lines but on them, NASA has adopted "on" as its preposition of choice.) Then Marshall will hand over responsibility for the telescope to the Goddard center. Goddard chose the scientific instruments that will fly on the telescope and will run the space telescope ground control center.

The Space Telescope Science Institute will select viewing targets for the observatory on the basis of proposals submitted by astronomers around the world. (European astronomers are guaranteed a minimum of 15 percent of the telescope's viewing time because the European Space Agency contributed equipment for the telescope—the faint-object camera and the solar arrays—worth 15 percent of the project's budget.) Technicians at Goddard will enter telescope pointing commands into computers that will relay the instructions to NASA's satellite tracking station in White Sands, New Mexico. The White Sands station will send the commands to a tracking and data relay satellite, and the TDRS will forward the commands to the orbiting telescope.

Data about light collected by the telescope will be packaged into electronic signals, which will follow this same path in reverse, ending at the Space Telescope Science Institute. Scientists there will decipher and catalog the data and make it available for study, first to the astronomer who proposed the observation and then, after a year, to anyone else who's interested.

As the wait drags on, people in these organizations are finding ways to fill their time. Tests that were to take place over the course of days have been stretched out to last for weeks. Additional tests have been scheduled, and new tasks and goals have been set. But many people who were supposed to be hired by these organizations have not been, and some workers have been "offloaded"—bureaucratese for laid off.

When project managers and scientists talk about the project, what is most striking is the virtual schizophrenia with which many of them view the launch postponement. There is, for example, the view of Riccardo Giacconi, director of the Space Telescope Science Institute: "Well, we thank God that we have this extra time." The institute's software—the computer programs that will let astronomers propose viewing targets for the telescope and will interpret the telescope's data—is very complex, he explains. Extra time is proving useful for "understanding this software, testing it, practicing using it. It's a very time-consuming process. Had we launched in '86, the telescope would have worked, of course, but the efficiency would have been very low. Every day up there in orbit costs a lot of money .... The whole system is being tested and worked on, to tune it up to its highest efficiency."

Then, almost in the same breath, Giacconi laments the harm done to employee morale. "It's like training for the Olympics. You get all ready for the event to happen at a certain time, and then it doesn't, and there's a certain amount of disappointment. In general, these very long delays have been very damaging to space astronomy, especially for the young people who should be doing lots of work now, establishing their names. They're in their most productive years now, and there is nothing for them to do."

Giacconi is an emphatic and vivacious man, inclined, perhaps, to accentuate the positive. To say, for example, that "there's a certain amount of disappointment" in the face of an indeterminate wait for the telescope mission may be

The telescope is undergoing a full array of tests, but astronomers are eager for the only one that counts.

the astronomical understatement of the decade.

Ed Weiler, space telescope program scientist at NASA headquarters, begins his appraisal by saying, "No delay is good." But then he adds: "The nice part is that we'll be able . . . to do many more things before launch, and we should get better science at launch. The down side is that we have to wait two years to do that science, and we want to do that science now. Probably that down side outweighs the benefits."

Goddard's deputy director of flight projects, Frank Carr, also takes a good news/bad news approach. "There are a number of impacts of the post-*Challenger* delays, and not all of the impacts are negative," he says. "We're trying to take advantage of the delay to do a very careful, methodical, thorough testing of all the ground systems, which is usually done in a hurry with a launch date breathing down your neck. With the launch pressure removed, we can do this in a much more orderly way . . . and incorporate some systems which would not otherwise have been ready in time for launch.

"For example," he notes, "we have extended the abilities of the telescope to image targets that move." If a scientist wanted to study a volcano on one of Jupiter's moons, for instance, Goddard's computer programs would have to take a complex set of motions into account in order to point the telescope precisely: the moon would be orbiting Jupiter, the telescope would be orbiting Earth, and Jupiter and Earth would be orbiting the sun. If the telescope had gone into orbit in 1986, this planetary tracking maneuver would have been impossible until several months after launch. Now it should be available shortly after the telescope arrives in space.

"Turning to the negative side," Carr continues, "the program had a fair amount of momentum in January '86, and a lot of that has been lost. A launch in October '86 would have been a sporty proposition, but I'm convinced we could have done it." Then he turns to personnel worries: "With the attrition which we have . . . there's always the risk of the loss of critical skills. To date that hasn't meant that the whole house of cards has fallen in by any stretch of the imagination. But conceivably it could."

Lockheed Missiles & Space Company, Inc.

Kathy Sullivan has lots of hands-on experience with the observatory, which she hopes to escort into space.

Astronauts will make orbital house calls every few years to repair or replace ailing telescope parts.

Others throughout the project echo these views; there is almost universal acknowledgment of the utility of two extra years on the ground, coupled with widespread worries about morale and the loss of skilled workers.

One useful product of the additional time may be more power for the telescope. In tests conducted last summer, engineers learned that the telescope's solar arrays produced slightly less power than anticipated and, to compound the problem, the telescope's instruments required more power than expected. The current combination of batteries and solar arrays will be barely sufficient, but engineers are using their extra time to decide whether the telescope's nickel-cadmium batteries should be replaced with more powerful nickel-hydrogen batteries.

However advantageous the extra time may be, it does have its costs. There is the concrete expense of $7 million per month that NASA is paying for clean-room storage and other maintenance necessary to keep the project alive. Then there are the less quantifiable costs of jobs lost. The Marshall center already has cut its telescope project staff by two-thirds since January 1986. And everywhere, project managers are afraid that their remaining workers will get bored and leave.

Charles Pellerin, NASA's director of astrophysics, worries about attracting and retaining project scientists: "I like to keep a stiff upper lip, but it's a terrible blow." Pellerin's concern extends beyond the need to maintain interest among individuals—in many cases it is even more important to keep groups of scientists intact. "Universities have set up teams to deal with information from the telescope—professors and graduate students—and they're not going to stay together forever," he explains. "It's one thing to say that the universe has been around for 15 billion years and an extra two years isn't going to make any difference, but when you're looking ten of the best scientists in the United States in the eye and telling them they have to wait two years, well, that's quite a different story."

Maybe what these scientists need is a

history lesson. For long-time space telescope advocates, two years is a drop in the bucket. As long ago as 1923, German rocket pioneer Hermann Oberth wrote a futuristic novella featuring telescopes launched above Earth's atmosphere to peer deep into space. Almost simultaneously, U.S. astronomer Edwin P. Hubble revolutionized the field of astronomy with his discovery of galaxies beyond the Milky Way, and his hypothesis that the universe is expanding. In 1946 another U.S. astronomer, Lyman Spitzer Jr., revived and elaborated on the space-based telescope idea in a 1946 think-tank report. (Oberth and Spitzer are eagerly awaiting the launch of the observatory, named in honor of their colleague, who died in 1953.) Although *Sputnik I*'s inaugural orbit was still more than a decade away, astronomers took Spitzer's proposal seriously. And once the idea caught their attention, it was not easily dismissed.

By the 1970s an Earth-orbiting telescope sounded plausible enough that Congress started responding to astronomers lobbying for one. Finally, in 1977 Congress approved funding for a "Large Space Telescope" to be launched in 1983. Ten years, one name change, and many design alterations later, the $1.4 billion Hubble Space Telescope has yet to reach space.

At Kennedy Space Center, workers are preparing to resume shuttle launches in 1988, when *Discovery* is scheduled to carry a TDRS into space. The shuttle will launch two classified Department of Defense payloads and one more TDRS before the space telescope goes up on *Atlantis* nine months later. NASA won't launch the telescope until at least one, and preferably both, of these TDRSs are in orbit, since it is through the TDRS network that ground controllers will communicate with the telescope.

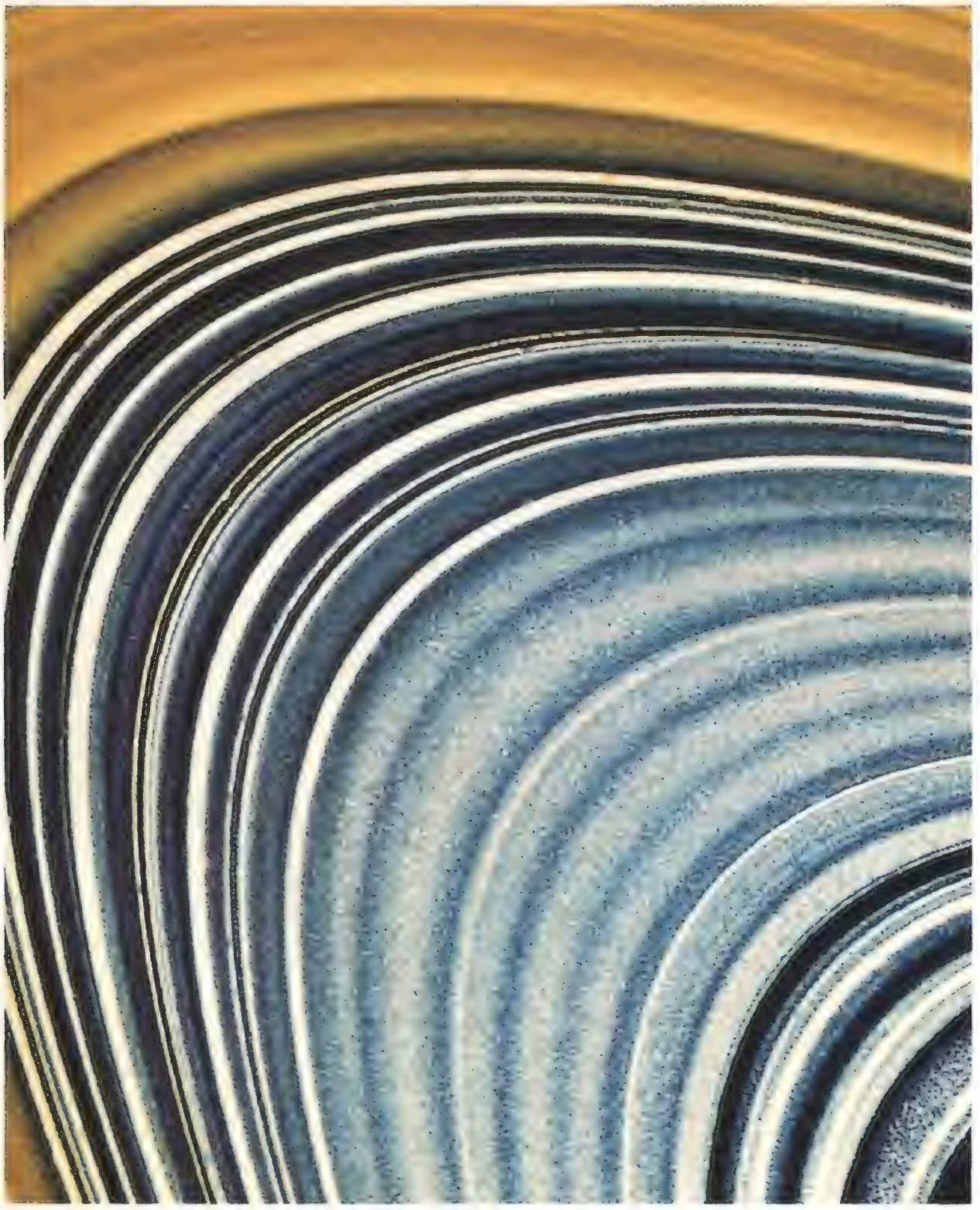
Being fifth in line for a shuttle launch is nothing to sneeze at these days. For years NASA has been calling the Hubble Space Telescope its "most significant scientific payload of the '80s." And the telescope may be even more important to NASA in the aftermath of the *Challenger* accident. Burt Edelson, NASA's outgoing associate administrator for space science and applications, understands the potential public relations value of the project. He told a conference of amateur astronomers in August 1986 that the telescope launch "will be a symbol to the world that NASA is back in business and pushing forward in its mission to do great things."

Meanwhile, back in Houston, Hawley, McCandless, and Sullivan are keeping busy. In April 1986 NASA named Hawley to represent the astronaut office in a mission development group, a job in which he acts as a liaison between shuttle payload designers and the astronauts who will deliver the payloads into space. McCandless still spends about three-quarters of his time on work related to the space telescope: evaluating spacecraft test results, analyzing deployment and maintenance procedures, and rehearsing deployment with telescope mockups. The rest of his time is taken up with flying and administrative duties. Sullivan often joins McCandless in his telescope work, and she also devotes time to publicizing the report of the National Commission on Space, of which she was a member.

"We're eager to go whenever the program is ready," McCandless sums up. "I mean both the shuttle program and the telescope program. In the meantime, like everyone else, we're just making the best of it."

Voyager 2 *photographed Saturn's rings on the fly; the space telescope will look at them regularly.*

Jet Propulsion Laboratory



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BLACKLIONS
BLACKLIONS
BLACKLIONS

An early script for *Top Gun* called for the fighter pilot played by Tom Cruise to fall in love with an aerobics instructor. In the final version, of course, his maverick heart falls for a beautiful astrophysicist named Charlie Blackwood, played by Kelly McGillis. The change certainly didn't hurt—the Paramount Pictures production became last year's top-grossing film.

But of the countless throngs who've seen *Top Gun*, few know that the Charlie Blackwood character was inspired by a real person: 32-year-old Christine Fox. A mathematician and analyst, she works for the Center for Naval Analyses, an independent civilian organization that conducts research for the U.S. Navy and Marine Corps.

From its headquarters in Alexandria, Virginia, the CNA assigns 37 field analysts like Fox to Naval commands around the world, where they bring a scientific approach to battle exercises. The analysts break down the complex movements of a mock combat, then identify problems and pinpoint how aircraft, ship, or submarine deployment can be improved. Their job is comparable to observing a high-speed chess game and then coaching the players on how they can improve.

Like her celluloid alter ego, Fox drives a sports car (Blackwood drove a Porsche; Fox prefers a less ostentatious dark blue Mazda RX-7). She stands a slim six feet tall, and like Charlie, she turns heads. But similarities to the movie character end at the surface.

Unlike Blackwood, Fox is no astrophysicist. Nor has she ever been assigned to the real Top Gun—the Navy's prestigious Fighter Weapons School at Miramar Naval Air Station outside San Diego. In fact, *Top Gun* might have been more realistic if the producers had stuck with the aerobics instructor.

Ask her how realistic the Charlie Blackwood role was and Fox covers her face with her hands and shakes her head. "They portrayed her as an instructor. You won't get a civilian instructor in Top Gun," she protests. "And she was telling the pilots how to

Role Model

For Christine Fox, *Top Gun* was more than just a movie.

by J.E. Farrell

Photographs by Chad Slattery

Tactics analyst Christine Fox, the inspiration for Top Gun*'s leading lady, finds herself the center of attention at Miramar Naval Air Station. Miramar is the home of the real Top Gun.*

fly. That would *never* work. What I do is not as jazzy. Analytically, it's very *interesting*, but it's not as jazzy."

Some might accuse her of false modesty. For her work Fox has flown in a B-52 bomber and even in an exotic electronics warfare training airplane—the NKC-135. She has been aboard an E-2C Hawkeye surveillance airplane as it tracked the frenzied combat maneuvers of Navy fighters during a training exercise. Four years ago, she was the first woman from the CNA to work aboard an aircraft carrier during mock combat.

In the movie, Charlie Blackwood worked directly with fighter pilots at Top Gun. Although Fox did work at Miramar, she had only occasional contact with Top Gun instructors, who worked in a nearby building and sometimes incorporated suggestions made by Fox and other analysts into their lectures. Her actual assignment, however, was to the commander of the Fighter Airborne Early Warning Wing, Pacific, which includes 16 F-14A Tomcat squadrons and eight E-2C Hawkeye squadrons of the Pacific Fleet. While assigned to the wing's headquarters at Miramar, she helped devise strategies for defending the airspace around the Navy's ships.

Analysis of aerial combat is an inexact science. With one E-2C and two F-14A

Aerial warfare has entered the Computer Age. Fox helps adapt tactics to the new technology.

Fox discusses tactics at a war game seminar. A civilian, she can move easily among ranks.

squadrons normally aboard a carrier, the tactics that best exploit the airplanes' sophisticated radars and weapons become complicated. Add the carrier's offensive arm—its squadrons of strike aircraft and medium bombers—and its antisubmarine airplanes and search-and-rescue helicopters, and the complexities multiply.

One exercise Fox worked on, named "Hey, Rube," involved the jamming of fighters' electronics and communications. " 'Hey, Rube' is a call used by carnival workers when they're in trouble," explains Fox. "When the jamming of electronic systems was first introduced into a mock battle, it raised such havoc that the 'Hey, Rube' name seemed appropriate." Fox worked with the squadrons to modify the exercise's tactics (because it's classified she doesn't go into detail), then discussed the changes with the officers involved.

She has also spent weeks writing a small computer program to isolate a tactic's key elements, then worked with a programmer to fit her findings into a war game computer.

The title "Earthbound Analyst" is carved in a wooden plaque on Fox's desk, a memento of another Miramar episode. "In this particular exercise, an air wing commander thought things had gone really well," she recalls. "I was in charge of reconstructing the event, and things didn't go as well as he'd thought. That happens sometimes when the people who fly can see only their small part of the whole exercise. Unfortunately, the air wing commander found it really hard to believe that I could tell him things didn't go well based on my papers alone, even though I hadn't flown in the exercise. Well, he sent a message all over my command about my results: 'How can earthbound analysts understand the problem?' "

After he cooled down, the commander realized that Fox was correct and called her in for a friendly meeting. "The current staff presented the plaque to me," she says. "It's a good reminder that I have to make sure my information is tight and that I can justify it."

Earthbound analyst Fox turned into astrophysicist Blackwood mostly by chance. The original role called for " 'an '80s woman,' whatever that means," shrugs Fox. "The script was rewritten a couple of times. They wanted a romantic interest for Tom Cruise but couldn't think of a way for a woman to get into the story. They started out with a Naval officer, but the Navy didn't want that. Then they fell back to an aerobics teacher that he meets at the officers' club. But I heard that Kelly McGillis didn't like that."

Paramount mentioned the problem to Rear Admiral Thomas J. Cassidy, who was the Navy liaison for *Top Gun* and Fox's boss while she was at Miramar. "He said, 'I don't know why you're having so much trouble. I've got the answer right here,' " Fox says.

When she stepped into the admiral's office, the producer and director gaped. "They made a lot of jokes like, 'Why don't *you* just play the role?' and 'Where's your Screen Actor's Guild card?' " she recalls. "So I met with the producer, director, and screenwriter,

FIGHTERTOW

N U.S.A.

Overleaf: Top Gun pilots train at "Fightertown U.S.A." It's hard to forget where they are.

Fox enjoys the personal contact in her job. Some initially dismiss her work, but most come around.

and spent a day showing Kelly McGillis around and explaining what I do. I really liked her a lot. A couple of times during the filming she called me because she thought the script wasn't right and wanted to get my opinion."

About clothes, for example: McGillis objected to donning seamed stockings, black spike heels, and a leather skirt for a classroom scene. She called Fox, who wears tailored suits and dresses on the job, and asked her to come to the set and help to persuade director Tony Scott that the clothes were inappropriate. Hollywood being Hollywood, "it didn't do any good," Fox says. "They made her wear them anyway."

Fox saw *Top Gun* with a friend last year while on a training exercise in Hawaii. "It was a really eerie feeling," she recalls. "When I first met McGillis, she had gained a lot of weight for *Witness*, and she had brown hair. Next time I saw her, she had lost weight and dyed her hair blonde. My friend said that they'd made her look like me. It was spooky."

With *Top Gun* a box office smash and Hollywood a publicity-hungry town, why didn't the world hear more about the real person behind Charlie Blackwood? "Christine does not like publicity," explains Phil E. DePoy, president of the CNA, itself a publicity-shy organization that asked the *Top Gun* producers to keep the affiliation of the astrophysicist vague. "We got a lot of calls here after the movie came out, but we pretty much protected her."

The CNA is the fourth military research organization Fox has worked for since she graduated from college in 1976. The 430-member organization, which has an annual budget of $35 million, is one of 30 federally funded research and development centers that do analysis for the departments of defense and energy.

The center had hired several female field analysts before Fox joined in 1981, but because Congressional policy prohibits women from engaging in combat, the Navy had hesitated to allow women to participate in combat exercises. Fox was the first woman the CNA put aboard a ship to work. "We worried about it," admits DePoy.

"A lot of people on the carrier didn't know I was going to be there," Fox remembers. "There were people falling down in the aisles, hooting and hollering." She laughs. "I felt like I wanted to keep to the areas of the ship where they knew I was there."

"She did push back the frontiers," DePoy says. "We recently put two women aboard the battleship *Iowa* and nobody even noticed."

"After the movie came out I thought about trying to let women know what my job is really like," Fox says. "I want to tell them it's really fun and that they might think about doing it."

Anyone so inclined would do well to share Fox's interests in mathematics and science. She earned her undergraduate degree in mathematics and her master's in applied mathematics at George Mason University in Fairfax, Virginia. An only child, she attributes her mathematical interests to her father, a retired nuclear engineer who was a noncommissioned officer in the Navy for 20 years. "My father felt that math was the key to most of the sciences," says Fox. "He always said that if he had acquired a better understanding of math, nuclear engineering would have come easier to him."

Fox also likes the personal contact in her work. "I try to interact with the squadron as much as possible. The pilots come back and tell me, 'Hey, you're crazy if you think that will work' or 'It's true, it did work!' It's a lot of fun."

One of her chief complaints about *Top Gun* is the chilliness imposed on the character of Blackwood. "They wanted her to be professional," says Fox. "I can see that. But I think you can be professional and still like the people you work with and like the job they do. If you're going to try to help somebody improve his tactics, you don't have a chance of getting them to listen to anything you say if you don't understand what they do."

Some people in the mostly male military still won't listen, and Fox occasionally encounters men who openly doubt her abilities because of her gender. "I think if you do your homework and your job, eventually they won't care who you are. There are always people who will never come around," she says with a gesture of dismissal. "I just don't expend a lot of effort with them."

Field analysts are reassigned at least every two years to maintain their inde-

Fox shudders when people mention a Top Gun *sequel. "I assume they're giving me a hard time," she says.*

pendent points of view. Fox says she enjoys the change in work, but "the personal aspects of moving are a little bit of a drag. I've moved three times in the last three years." Last November, Fox was assigned to the Tactical Training Group, Pacific, a school for battle group commanders located at Point Loma, just north of San Diego. She now analyzes tactics for an entire battle group, which may consist of 10 surface ships, 70 aircraft, and several submarines.

When questioned about working for the military, she pauses. "I usually don't say very much. I'm not nearly as aggressive or as bloodthirsty as the fighter pilots are. I think what they do is important and I'm proud if I can contribute to it. I don't like war, but I believe in a strong defense to prevent war. It's hard to explain that to someone who doesn't share that philosophy. I think *Top Gun* and its popularity is part of a changing sentiment toward the military."

But Fox is happy to remain a civilian. "I have the best of all worlds. I'm an analyst. I'm not in operations. There aren't too many opportunities to do analysis in the Navy. It does have its postgraduate school, but in the fleet the number-one priority is conducting operations. You also need rank and promotion to get ahead. If I were a lieutenant, I'd have to brief my superior, and it would go through three more people before it reached the admiral. I have a lot more freedom this way."

Although she admires the pilots she works with, she doesn't plan to become one herself. After working with the likes of F-14s and B-52s, the thought of piloting a small airplane seems tame. "I *would* love to go up as a passenger in a tactical jet," she says, but otherwise, Christine Fox is content to remain an earthbound analyst.

Essay

Space Station: The Clock Is Ticking

Despite their differences, the United States and its allies should press toward a partnership.

by John Logsdon

The current debate surrounding the National Aeronautics and Space Administration's space station program tends to overlook the importance of the station as a demonstration that the United States and its closest allies can collaborate in a complex, long-term endeavor. Assuming the program survives most of its domestic troubles, which appears likely, one big question remains: Can the station be built and operated successfully as an international partnership? It is certainly possible the partners will not be able to agree on major issues and that the United States and its allies will follow separate paths to the final frontier. Such an outcome must be avoided; the space station should be international.

Cooperating with the United States has helped Europe, Japan, and Canada to develop significant space capabilities; this country has received significant foreign policy benefits in return. Now the United States is trying to link its allies' capabilities more closely to its own activities, rather than watching the allies emerge as independent competitors in space in the early 21st century. The space station program is the means by which this coupling of destinies is to be accomplished.

In his 1984 State of the Union address, Ronald Reagan directed NASA to develop a permanently manned space station and proclaimed, "NASA will invite other countries to participate so that we can strengthen peace, build prosperity, and expand freedom for all who share our goals." These are noble aspirations, and the political incentives to forge a cooperative program are high. U.S. alliances are at stake.

Shortly after Reagan's speech, James Beggs, then the administrator of NASA, visited the capitals of Europe, Japan, and Canada to extend a formal U.S. offer to consider participating in a space station. Within a year, all the allies accepted the invitation and began to discuss details of the collaboration. Their goal was to come to an agreement before contracts to develop the station are awarded late in 1987. Pressure to reach agreement soon is intense, but each prospective partner brings different objectives to the bargaining table.

Europe views its involvement as a way to gain experience for developing its own space station and to conduct microgravity research. Japan, which passed up a chance to cooperate in post-Apollo programs at a time when its own space capabilities were not developed enough, is determined to seize the opportunity this time around to improve its space technology and gain experience in manned spaceflight. Canada wants to extend the relationship that began with its contribution of the remote-controlled manipulator arm to the space shuttle so that it can advance its capabilities in automation and robotics. All three partners will probably come to believe that the potential benefits of participation outweigh the inevitable compromises an agreement will necessitate.

Since the agreement in principle two years ago, each partner has been defining its hardware contributions and refining its negotiating position and objectives. And here, the United States has had more problems than its potential collaborators. The U.S. bargaining position, weakened by the disarray from the *Challenger* accident, today strains to accommodate pressures from Congress and industry to come away with the lion's share of the economic payoff, a foreign policy biased toward international cooperation, and the Department of Defense's insistence on access to the U.S. portions of the station for its research.

Some of the program's troubles are exclusively U.S.-made. NASA has changed the station design several times, and cost estimates have increased dramatically. Many people within the scientific community decry the diversion of resources from space science. And the jury is still out on whether the station should depend on the space shuttle.

So far, Europe has been the most demanding. It is determined not to be treated as a junior partner. Some $2 billion of the European Space Agency budget is set aside for a pressurized laboratory for the station's core and an unmanned platform in polar orbit. Europe would also like its own crew-tended orbiting laboratory, which would dock with the station only for servicing and resupply. Such a laboratory would eventually allow Europe to develop an independent space station.

During the 1970s, ESA built Spacelab, a pressurized laboratory designed to fit the shuttle payload bay, at a cost of $1 billion. But because of the terms of that agreement it ended up turning Spacelab over to the United States and now has to pay full price for its use. Europe does not intend to repeat this experience. It wants control of its own hardware, and it wants to decide what kind of research will be conducted in its laboratory. Europe strongly opposes any suggestion of a U.S. veto over such activities.

The Japanese Experiment Module (JEM), a self-contained research facility, will cost approximately $1.5 billion. Japan wants to conduct experiments aboard the station in privacy, using its own transport and communication systems and the JEM's own docking port, and to protect the results, promising only to meet safety guidelines. Japan would open the JEM to others only if it retains control over Japanese experiments. And some Japanese are particularly troubled by the idea of national security experiments aboard the station.

Canada is concerned about both the control issue and the national security involvement. Its main contribution will be a Mobile Servicing Center with a remote-controlled manipulator arm based on the shuttle's and involving advanced automation and robotics. Canada also fears that the desire of U.S. firms to retain such advanced applications for themselves could result in restrictions that would erode the value of Canada's $500 million investment in technological advancement.

The partners are being asked to trust U.S. leadership and resolve. The United States must ask itself whether it really offers a basis for such trust and whether it should bend a little.

At the heart of the partners' differences, of course, is the issue of control: How will priorities be set, and who will prevail when conflicts arise? Allocating costs of operation and determining how much of the station's resources each partner can use will not be easy. Such questions should be raised early on, but there are no answers now. The partnership must therefore include a mechanism to resolve such conflicts as they arise.

The current U.S. negotiating position reflects tough bargaining within the government, with commercial and national security communities in particular concerned that too many U.S. interests were being compromised in order to gain international participation. The final position: for providing the station's "utilities"—living space, energy, waste disposal, most transportation and logistics—and bearing over 80 percent of the costs, the United States should have what amounts to veto power. One overstated justification for the station was the expected payoff in areas affecting U.S. competitiveness, so Congress, the Department of Commerce, and industry are pressing to limit potential competitors' access.

The Department of Defense initially said it had no need for the station. Defense secretary Caspar Weinberger had strongly opposed it. However, space defense research and a rethinking of the role of military personnel in space have led Defense to reverse its view and to demand that U.S. partners explicitly acknowledge its right to conduct national security research aboard the station. NASA has maintained that the space station will be open to all users with peaceful intentions—including the Department of Defense. Extensive weapons-related research was unlikely, NASA implied. But the thought of Strategic Defense Initiative experiments aboard the space station makes other governments uneasy.

The current U.S. position lessens the desire of Europe, Japan, and Canada to sign on, so the stage may be set for the collapse of the emerging partnership.

Disappointments and conflicts may persist, though it is incorrect to argue, as some have, that a basis of agreement for an enduring partnership in such a complex enterprise can't be found. Agreement with the partners forces compromises that could undercut U.S. objectives, the skeptics suggest, and the United States should go it alone.

As appealing as this reasoning may be, it should not be pursued. The Reagan vision of a space station partnership is a political one, driven by fundamental national interests in preserving alliances and U.S. leadership among industrial democracies, as well as in opening up space through peaceful cooperation instead of international competition. If the broad objectives lose out to the narrow, nationalistic concerns of the United States and its allies, global harmony will suffer.

The United States is asking a lot. It wants its partners to stake their future in space on its ability to provide wise policy and a sound technical foundation. The partners are being asked to postpone their claim to independence in space and to trust U.S. leadership and resolve. The United States must ask itself whether it really offers a basis for such trust, and whether it should bend a little so that international cooperation can survive. Perhaps a momentary lack of national self-confidence (and not just in space) has scared the United States into thinking that its foreign partners will skim the cream from the station. Instead of giving in to this fear, the United States should work on restoring its confidence in developing the economic potentials of space.

The partners ultimately must recognize that the United States should have the dominant role in managing the space station, given the overwhelming share of investment and operating costs we have assumed. There must be a way to incorporate into an agreement the traditional U.S. respect for minority interests as well as a sufficient measure of U.S. control. And given the political realities favoring Defense's interest in the station, the partners should accept military access to the station's research facilities.

Thomas Hughes, president of the Carnegie Endowment for International Peace, recently lamented "the twilight of internationalism," noting that leaders around the world are losing the idealism and optimism that have fostered international collaboration. He denounced the resurgence of nationalistic approaches to resolving today's issues. How we handle the next step toward opening space may tell us whether the trend of nationalism can be reversed.

Of boys,
balsa,
and
beginnings.

by Daniel Pinkwater

Illustrations by Tony Auth

Rhapsody in Glue

I can remember a time when a boy, hearing an airplane, might run out of the house and peer into the sky, shading his eyes with his hand. He would call to other boys, and they too would look upward. Some of us might not have been entirely clear as to what an airplane was, but I remember that the sight of one was thrilling.

(Looking up) "There! There it is!"

"Yep. It sure is!"

"Yep."

"It's *waay* up there!"

"Yep."

I grant that we may not have expressed it very well, but we knew how we felt. We thought airplanes were beautiful. At the age of five, though, we did not use the word "beautiful." Lash LaRue would not have used it. Hopalong Cassidy would never have said it. We were already learning to be inarticulate louts, but the tiny machine in the sky stirred our souls and evoked an emotion we were years away from acknowledging in connection with females. It combined admiration and yearning with a need to pretend we knew what we were talking about.

"That's a mail plane," one might say, and the others would all agree.

Or "That's a German plane" (we were at war), and we would narrow our eyes and project our hatred upward.

The fact of airplanes constituted a mystery. It was part of the secret kid subculture that flourished then, and is thought not to flourish so much now, but does. I don't recall any adults leading us out of the darkness of mythopoeic thought and primitive ritual. We were taught a standard curriculum at school and the essential manners and morals at home; otherwise, we were mostly on our own. Given the richness of the backyard culture, I was and am grateful for this benign neglect. For the first eight or nine years, we were left to develop along the lines of the less progressive natives of New Guinea.

Those very natives, I understand, are the world's most ardent model airplane builders. Their models, which are full-scale or at least large, are intended to work as decoys of a sort, enticing cargo-laden planes to land in their part of the jungle. At least that's the story they gave the anthropologists. I can only report what I saw on educational TV.

There is something to be said for the sympathetic magic

theory of model building. Paleolithic cave dwellers drew models of animals they hoped to encounter. The New Guineans may well have fashioned airplanes in hopes of getting the contents of one—or just making the distant thing come close. I build a model of a portion of my childhood, and as I do, it becomes momentarily vivid. Model building appears to be a basic inclination, particularly of primitive man, which includes all boys.

I suppose some girls built models, even then, but I wouldn't have known. Females hardly existed in the Papuan jungle I inhabited in the 1940s and early '50s. Objects of love, desire, and frustration were made of balsa wood and tissue paper.

I recently visited a hobby shop, and what I saw made me profoundly sad. All the boxes of unassembled wonders contained pieces of plastic! There were a few wooden models suspended on wires from the ceiling, but these had the look of museum pieces, relics of decades past. The modern model builder snaps together injection-molded parts, which sometimes do not even require the application of glue. The skill is in the painting of the assembled project—mere occupational therapy. Painting was just the last stage of the process when I was a Neanderthal nipper.

The plastic model kit had a wooden antecedent: the "solid" model. Depending on its price, this kit might consist of a partially formed fuselage, which required a good deal of sanding and shaping, or, in the super-economy class, a simple block, which the young craftsman was supposed to carve with his X-acto knife. The kit included paper templates, which were to be glued to cardboard and cut out, then used at specific places on the fuselage and wings to guide the builder in attaining the proper contours.

Looked down upon as a diversion for little kids, these solid jobs were actually impossible to build, and the results never looked like anything but potatoes with wings. To compound the frustration, the devils who made up these kits included an envelope of glue in the form of a powder that, when mixed with

water, produced a yellowish mess with the consistency of Swiss health cereal and the sticking power of thin air. Insignia were printed in two—or, if you were lucky, three—colors on the sheet of paper with the templates and confusing instructions. The idea was to cut out the insignia, and in a last-ditch effort to make the pathetic thing look like an airplane, stick them on with the same horrible, lumpy paste.

Once upon a time, some early lowbrow discovered that he could jam his favorite rock into the end of a cleft stick, thereby conferring on the rock enough arc and velocity to make it useful for getting food and gaining the respect of the neighbors. It was with much the same excitement that I came upon Testor's model airplane cement, eventually replaced by the revolutionary Quick-Drying variety (the experience of which innovation prepared me emotionally to enter the Computer Age without missing a beat). With the magical ambroid, I was able to keep solid models from falling apart as I built them, and at the age of seven or eight, I not only made a putative Grumman Wildcat with both wings attached but glued everything I owned to everything else I owned, with satisfying results. It was a short step from Testor's cement to Testor's model airplane dope. The finished product still looked like a potato, but the parts remained stuck on, and the paint looked shiny and good. I was on the high road to craftsmanship.

Craftsmanship was embodied in the "stick" model. These kits came in boxes much like the ones spaghetti comes in. They contained a multitude of thin strips of balsa wood that actually looked like spaghetti, several equally thin sheets of balsa imprinted with a variety of curious shapes, one folded sheet of tissue paper, and a sheet of plans.

Newspaper would be spread on the dining room table, with admonishments from Mother about the fate of a boy who got a single drop of glue on the finish. On top of the newspaper a sheet of cardboard would be placed, on top of the cardboard, the sheet of plans, and over that, waxed paper—all held in place with tape or pins. This was the assembly stage for the

airplane, which then existed only as an image on the box and in the mind of the aspirant.

The shapes printed on the sheet of balsa had numbers printed on them and represented fuselage bulkheads, wing spars, and other components. These shapes, which mostly appeared as concentric ovals, rectangles, and crescents, had square notches around the perimeters where the spaghetti-like stringers would be glued (the joints were held in place with pins until the glue was dry). With single-edged razor blade or trusty X-acto knife, the model maker would cut each part out with infinite care. The highest-grade kit had precut components, but who could afford such luxury?

The wings were built by laying the parts directly on the plans, with the spars positioned on double lines, each labeled with the number of the spar. As the project took shape on the waxy surface, pins bristling, it began to look like a dissection tray holding the skeleton of some improbable creature.

And the whole shaky, amazing, desperate enterprise would have to be shifted from the table when supper was ready.

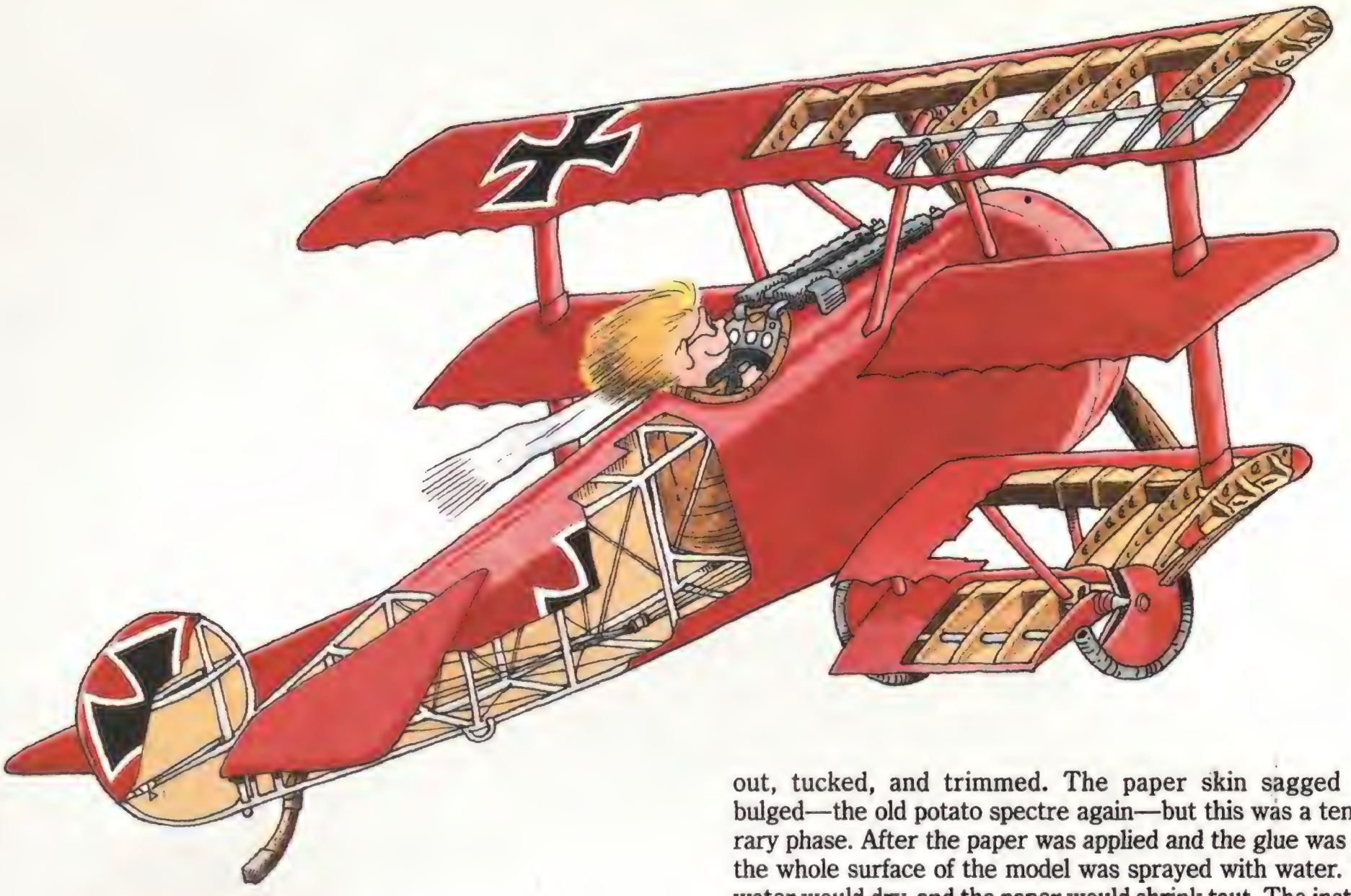
I don't recall ever being taught any of these techniques—that is to say, no kindly or professional adult ever sat me down and explained how to build a model airplane. The skills were picked up partly from reading the instructions and partly from trial and error, conversation, and glimpses of another kid's model-in-progress. My older brother also gave me some tips, having built *his* model.

Which brings me to the consideration I find most interesting: I never regarded building models as a hobby. I know that some do, and no doubt people who were kids in school with me are building them to this day. But for me and most kids I knew, it was something you did for a certain period of time. It wasn't clear when this period would end, but usually the event would coincide with adolescence taking a good hold. Ideally, it would also be at a point marked by the creation of a masterpiece. Then you could hand down your venerable piece of chipboard to a younger kid and march on toward manhood.

My own unsurpassable ultimate was the creditable completion of a Fokker Dr I triplane from a 25-cent Comet kit. These kits were the cheapest on the market, and they were execrable things. For your quarter you got a tiny spaghetti box containing a sheet of splintery, frangible balsa, with fuselage cross-sections and wing ribs murkily printed in blue, and tiny blue blobs indicating the notches to be cut out for the stringers. The stringers themselves were not precut but had to be sliced out of another sheet of balsa as tricky and crumbly as the first. Only a brand-new razor blade and careful study of the grain of the wood would permit the cutting out of parts without the horrible material disintegrating.

To save on the cost of a second sheet of newsprint, the makers had printed plans and instructions in a fiendishly tiny, compacted, and abbreviated fashion on a sheet no larger than notebook paper. The plans looked as though they might be the work of Albrecht Dürer in his solid-model days.

The actual model, if it could somehow be completed, was to



be a dazzlingly small miniature—The Lord's Prayer written on a grain of rice, the boy Mozart's violin. I was pretty sure no one had ever put one together. This was the ultimate challenge, the over-the-shoulder mirror shot at six clay pigeons.

There are moments when you know you are ready. With absolute certainty, I laid out my portable studio on the dining room table.

I entered into a kind of trance. My mind was clear. I rose above the seething turmoil of family life. Parents, siblings, pets—all merged into an unobtrusive murmur. I was calm. I was prepared. To focus my meditative state, I employed the old Hindu trick of listening to the radio. "Bob and Ray" and "X Minus One" provided mantras as I worked.

Days at school were dream-like, serene. I did not get involved. I was saving my strength for the great work taking place at home.

The delicate wings, tail, and fuselage were constructed. Then the undercarriage went on. The tail skid. The skeleton was assembled. It was complete.

It was beautiful.

It is said that artists love their sketches more than their finished paintings. I once saw an X-ray of a Rembrandt; it showed that the master had laid the foundation for his picture by putting down darks and lights in what looked like a first-class abstract expressionist work. I wonder if he took a day to admire it before he obscured the vigorous brushstrokes with an image more suitable for his time.

The tissue paper supplied with the kit was precisely enough to cover the finished airplane—there wasn't a square inch to spare. Careful cutting was called for. Glue was applied at intervals to the balsa skeleton, and the paper was smoothed out, tucked, and trimmed. The paper skin sagged and bulged—the old potato spectre again—but this was a temporary phase. After the paper was applied and the glue was dry, the whole surface of the model was sprayed with water. The water would dry, and the paper would shrink taut. The instructions suggested the use of a perfume atomizer or an L-shaped tube affair through which one blew so that one leg of the L drew water from a glass. But the only method I had ever seen employed was the mouth spritz, such as ironers use. One practiced this in the bathroom or on one's little brother until a fine even spray could be produced.

Some model builders—grown ones with plenty of money—were given to covering their models with clear acetate instead of tissue paper and leaving them unpainted to show off the excellence of the construction. Rembrandt and I would know that this parading of craft was vulgar and a violation of the Rules of Art.

And painting, the last stage—the *only* stage for the wretched modern plastic model assembler—was sheer joy for me. The German airplanes of World War I displayed a lot of style when it came to color, and most of the Fokkers were bright red—which was what had interested me in the little triplane to begin with. Now I got to smooth the rich, red paint onto the tissue, which had shrunken to follow every contour of the structure. Two coats! And black for the details. When the dope was dry, the thing gleamed.

It looked—and no doubt smelled—not much different from the full-size original on the day it had rolled out of the factory. And it could *fly!* Not that much of a flight would ever be ventured with such a treasure, but give it a tentative shove and it would take to the air eagerly. A single test glide was undertaken in the living room. It even landed properly, rolling to a stop as though the Red Baron himself were at the stick.

I may have built one or two models after that, but they did not signify. I knew—or sensed—that I would never experience such a feeling of triumph again. I had earned my wings—three of them.

The potential is boundless.

Potential. In many people it goes unrecognized, undeveloped and unused. That's tragic. Because when a person's potential is never developed a terrible thing happens: nothing.

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Developing potential is part of what aiming high is all about. If we all live up to our potential as individuals, there will be no limits to the potential of our nation.

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AIR FORCE

A great way of life.

While the Thunderbirds perform at center stage, the support team takes a breather in the wings.

Another Opening, Another Show

by Patricia Trenner

Photographs by James Sugar/Black Star

Inside the casinos, bleary-eyed gamblers work the rows of green felt-top tables and nurse Bloody Marys as croupiers softly chant the fall of the cards. Outside, the sky brightens as dawn breaks. The marquee lights fade and the Strip sheds its glitter to reveal block after block of tired buildings lining deserted streets.

As night ends in Las Vegas, just a few miles to the northeast the day shift at Nellis Air Force Base is getting started. Here the morning sun outlines razor-sharp peaks that rise like creases around the Mojave Desert. At the base's main gate, security officers scan the on-

coming rush hour traffic for proper stickers and wave white-gloved hands to summon those who may enter.

On the hangar ramps, ground fog loosens its embrace on gunmetal gray F-15s and camouflaged F-5s. A rank of enlisted men, like a skirmish line of ghosts in the fog, moves methodically down a taxiway, searching for pebbles, bolts, and anything else that could be sucked into an engine air intake and nick a whirling compressor blade.

Amid the jumbled architecture of Nellis, a gleaming white two-story hangar rises above a line of rambling buildings that parallels the ramp. The hangar presides over a line of pristine F-16s painted red, white, and blue, and it marks home base for the Thunderbirds, the United States Air Force Air Demonstration Squadron.

Today the team is home for a short stay between shows, and although it will be that rare and welcome commodity—the slow day—most team members arrive at the hangar by 0700. Lieutenant Colonel Roger Riggs, team leader, has a pile of paperwork to wade through this morning and a few miles to run this afternoon. "Three to five miles. I try to exercise 30 minutes every day," he says. Staff Sergeant Ann Skinner decides the paint on the Number Five air-

Engine checks are part of a stringent maintenance program with a flawless record: not one show has ever been canceled for mechanical problems.

The Boss (far right) and fellow officers gather in loose formation at one of the many ceremonies to honor new members and re-enlistments.

plane needs touching up. "Normally, the paint takes 48 hours to cure," she says, "but with the right amount of chemical accelerator, I can get it down to one hour." Staff Sergeant Jim Swenson, assistant crew chief for Number Eight, has been out on the ramp for an hour, cleaning the canopy with Windex and wiping the tires with Armor All. He wants his airplane perfect for a photo session.

Around the white hangar, the words "perfection" and "challenge" are used repeatedly. The team is obsessed with perfection in everything they do: anything less constitutes an unacceptable risk for airplanes flying within three feet of each other at upwards of 400 mph. The challenge is maintaining that perfection through 80 performances a year before audiences that can total 15 million. That calls for scrupulously maintained airplanes, formation flying so precise some people think it's orchestrated by computers, and constant applications of polish to airplanes, equipment, shoes, and image. The mission of the Thunderbirds is to support the service's recruiting and maintain the public's high opinion of its Air Force. "We're also in the entertainment business," says Major Jake Thorn, airshow narrator and advance man. "It's kind of

Ann Skinner finds that even a touch-up of the intricate paint scheme requires hours of masking (left).

Crew chiefs keep their charges immaculate, saying that they merely loan the airplanes to the pilots (below).

like being the rock stars of aviation."

The stars of the Thunderbird productions are six airplanes and their officer-pilots, but the credit for getting the show on the road goes to the 5 officers and 120 enlisted men and women who make up the support crew. For each show, they line up 50 hotel rooms, 22 cars and vans, dry cleaners, and press coverage, to say nothing of 10,000 gallons of jet fuel and nine drums of smoke oil. They churn out brochures, inscribe photos for VIPs, and produce a storm of correspondence. After each flight, they wipe down the airplanes as if the F-16s were high-strung racehorses. And between shows, they regroup at Nellis, tend to aircraft maintenance, and rehearse for the next performance.

"People think we just fall out of the sky, ready to do a show," says Captain Rich Savko, Thunderbird executive officer. But the team's preparation begins immediately after the last show of the year, when the coming March-to-November schedule is penciled in and replacements arrive for officers whose two-year assignments are up. Though the new arrivals are drawn from the Air Force elite, they still have to be molded into Thunderbirds.

Top Air Force fighter jocks typically have highly individualistic natures. But Thunderbird pilots are chosen for their ability to work as a team, both in the air and in the public eye. As many as 100 applications are received for each pilot vacancy, and from these, a group of candidates is selected and brought to Nellis for interviews, flying auditions, and informal evaluations.

"When they talk to us, they're going to give the answers we want to hear," Savko says. "So we have a little social thing, with the wives of the current team, the generals, and the appies [applicants]. We see how they interact, especially with the wives. Are they cordial? Snobbish? You'd be surprised what we pick up." After the final selection is made, the newcomers attend a charm school session at the Pentagon, in which they learn how to deal graciously with the public and the press.

Enlisted applicants, who fill administrative, clerical, and maintenance positions, are selected on the strength of performance reports, personal references, and photographs. A new member undergoes a 21-day training period, learning squadron operations and history before being awarded the Thunderbird emblem in a "patching" ceremony. "It's kind of like joining a college fraternity," says one initiate.

The fraternity consists largely of Type A personalities who are equipped to accommodate the team's obsession with perfection. "You need to give 120 percent of yourself 100 percent of the time," says Technical Sergeant Cheryl Pascal, who specializes in aircraft heating, cooling, and oxygen systems. An engine technician offers an example: "We got a maintenance directive that required removing and checking each engine. It estimated three weeks to do nine airplanes. We did it in three days."

This afternoon, Jim Benson, public affairs officer and Thunderbird Number 12, is in line for lunch at Burger King. A loudspeaker squawks out the orders as they come off the line. "Number 12, number 12: three-seventy-nine." Benson, accustomed to being paged by his Thunderbird number, starts for the counter, then realizes his ticket reads 18. It's difficult to relax and eat a normal meal at Nellis or on the road, he says—but that's life in the fast-food lane. "You put off meals—you don't want to be stuck in a line where you can't get back if you're needed." Savko says the endless series of receptions the team attends is no better. "They always serve chips and those little franks. I'd be surprised if we ate one balanced meal a day when we travel."

Still, team members remain extraordinarily healthy. Thorn, who manages an on-the-road pharmacy, attributes it to keeping busy. "And you get used to the pace," he says. "After a while, you don't even know what day it is—and it doesn't matter. You know where you're going and what you're going to do *that* day. Last year, Number Five got sick on Labor Day weekend. No, Memorial Day. The one in May—is that Memorial Day? Yeah. But generally it's very seldom that one of the pilots gets sick."

Though the squadron carries spare parts to every show site and even has spare engines positioned on either coast, there are no spare pilots. "We flew a five-ship show that day," Thorn says. "And we can even fly a four-ship show. The only time we wouldn't fly at all would be if Number One got sick. We can't fly without The Boss."

The Boss is Roger Riggs, who at age 39 has accumulated more than 3,000 hours of flight time, including some 400 combat hours in Southeast Asia. His is perhaps the mold in which all Thunder-

The shark-like maw of an air intake, which gobbles insects, pebbles, and dirt, undergoes cosmetic surgery (right).

bird pilots should be cast: tall and slender, blue-eyed and blonde, he exudes an all-American aura dear to the hearts of recruiting departments.

Riggs thrives on the synergy of the team. "The commander of a normal operations squadron might have 50 officers under him. Here I have not only an operations section but all the maintenance people as well. It's more of a challenge, but I think you end up a closer squadron. People work harder for you because they get to know you."

Still, spending 200 days a year on the road together inevitably leads to occasional friction. "If there's a conflict, we'll close the door and get it off our chest. I tell people they can get mad, but not for more than three minutes. Then you have to let it pass. That's our rule."

Back at the base, the hangars vibrate and conversations skip a beat every few minutes as flights depart in pairs, afterburners shimmering. Out on the ramp, Sergeant Dave Manfredi is running a routine engine check on Number Three prior to a practice flight. Every day the team is at home it schedules two dress rehearsals, complete with the march-down, a cadenced walk along the flight line with crew chiefs and assistants peeling off at their assigned aircraft.

On the second floor of the hangar, Technical Sergeant Ann Butterfield is slowly making her way through a stack of 16- by 20-inch matted photos of the F-16s flying over various landmarks. These will be distributed at show sites to those who have helped coordinate the team's visits. Butterfield inscribes the squadron's thanks on each one in painstaking calligraphy, filling in the name of the recipient from a long list provided by the public affairs office.

Across the hangar, Savko is editing and proofreading outgoing mail. "God forbid we should have an error! I can just hear, 'Look, the almighty Thunderbirds misspelled a word.' " There are also visitors to escort through the team's museum. And when the team is traveling, Savko fields occasional calls from families back home. "The car breaks down, there's a financial problem. Who else can they call?"

In an adjacent hangar, the corrosion control team is sanding Number Five for painting. A boom box is perched on an oil drum, and Huey Lewis and the News reverberates throughout the hangar at near-afterburner volume. Ann Skinner, wearing a blue uniform dusted with sanding fallout, masks off the red and white bands on the airplane's nose. "Number Five hits Mach 0.94 during the high-speed solo pass," she shouts. Another 0.06 and it would be cracking the sound barrier, which the pilots avoid. "That speed really stresses the paint," Skinner explains, "especially when it rains as hard as it did at last Sunday's show."

Skinner will let the paint cure for two days before the team leaves for a 10-day tour, with shows in Mississippi, Virginia, Florida, and North Carolina. As advance man, Thorn will precede them in the two-seat Number Eight airplane and attend to any last-minute glitches at the show sites. "Sometimes the support equipment promised is not there," he says. "The sponsor figures, 'Well, I'll wait until Major Thorn shows up. He'll take care of it.' And I'll have three hours to take care of it."

On departure day, a C-141 Starlifter reports to Nellis for tour duty. Between 50 and 60 team members stuff it full of equipment and suitcases and, following the little knot of F-16s, head for the first show site. When the Starlifter touches down at Langley Air Force Base in Hampton, Virginia, and taxis to a stop, the cramped passengers on the floor of the cargo hold stow their paperbacks and start unloading equipment. Almost every piece—smoke oil carts, hydraulic stands, even fire extinguishers—is painted in Thunderbird colors. The

team trundles lightweight equipment down the ramp followed by a dolly piled high with bolts of lint-free cloth and cases of Windex. "Swing that end around to the left," a sergeant directs. "My left?" "No, military left!" Tow bars and show ladders—metal rungs used to climb into the cockpits—are dispatched to the flight line. Next come dozens of standard-issue suitcases, neatly aligned alongside the aircraft. All that remains are golf bags, a rack of uniforms, softball equipment for a game with the Navy's Blue Angels support team in Pensacola, and a random pair of sneakers. At show time, the road crew will duck inside the C-141 to change into immaculate blue uniforms with white ascots that, a wearer confides, itch in the heat.

There is no need for a fast-food run today: local Thunderbird alumni have provided a six-foot submarine sandwich stuffed with cold cuts and cheese, and for dessert, plates of homemade brownies. Staff Sergeant Tony Pagán cuts precise wedges of the sub for the team members still aboard the C-141 and wraps the rest for the crew on the flight line. He even salvages some brownies.

Skinner, rag in one hand and wedge of sub in the other, is wiping down Number Five. Today she's on the morning shift, which will end at 2:30, just before the show begins. "I'll be ragging jets until then, but then I'll hit the concessions for a Coke and a burger."

The concessions have been doing a brisk business since late morning. Four hours remain before the Thunderbirds fly, but the dozens of aircraft on display have already attracted visitors carrying binoculars, coolers, and folding chairs.

A Bell UH-1 helicopter rumbles overhead, carrying Riggs and solo pilots Major Buzz Masters and Captain Tom Weiler. They are checking the placement of markers that designate the show's center and outer boundaries. Occasionally the helicopter drops down to hover over a checkpoint while the pilots match it with an aerial photo. "Flying a show is like playing golf," Riggs says. "You make the same swing, but you're always on a different course." The pilots will rehash the lay of the land in a preflight briefing, at which all present will end up banging on the table. "I guess we get kind of psyched up," Riggs says. "It's a tradition that started with a

The inner sanctum of a C-141 Starlifter transport aircraft doubles as the support team's dressing room at show time (above).

A mammoth sub and homemade brownies provided by a former Thunderbird are a cut above the usual fast-food rations (left).

Ann Butterfield's calligraphy personalizes hundreds of photographs for local dignitaries on the airshow circuit (right).

George C. von Kantor

The diamond formation turns heads in the VIP section, where squadron alumni critique every maneuver.

These performers never forget their lines. Thanks to the smoke system, neither will the audience (right).

previous commander. Everyone used to fall asleep during the briefing, so he'd beat on the table to wake them."

Before the opening march-down, pilots adjust their sunglasses and straighten their uniforms. "We rent perfect bodies that inflate to fill the uniforms," Jim Benson says. "And Thunderbirds never sweat, either."

At the communications trailer, which links Major Bill Pritchett, logistics officer, to the pilots, Staff Sergeant Cindy Sackett is handing out foam rubber earplugs and squadron members are applying dabs of white sunscreen. A jeep drives the length of the runway on a final check for the gravel or stray screws that produce FOD—foreign object damage—even though the surface was cleaned by a vacuum sweeper earlier in the day.

Opening march-down complete, six engines spin up to a whine, then take on a deeper note as the igniters light. "Beaks in the breeze," Riggs commands, signaling the pilots to turn their heads to the left and salute the crew chiefs as the aircraft taxi out.

"Ladies and gentlemen, Thunderbird Number One, Lieutenant Colonel Roger Riggs of Louisville, Kentucky." Thorn introduces each pilot over the public address system while the airplanes pose on the runway like beauty pageant contestants. Sackett, Airborne Video, cues the music: today's audience will hear snatches of "The Wild Blue Yonder" and the theme songs from *Star Wars*, *Saint Elmo's Fire*, and *Rocky*, among others. "Next year you might hear something from *Top Gun*," Thorn says.

Maintenance officer Captain Terry Williamson, Number 11, is wearing a headset that lets him eavesdrop on cockpit conversations. "Let's fly an airshow," he mutters, pacing the ramp like a football coach. Williamson holds that if there were ever an aircraft problem, "it's going to be with the operator, not the equipment. We always give them a good airplane." Indeed, in the squadron's 34-year history, not one performance has been canceled for maintenance reasons. And today's kicks off perfectly as the formation scoots down the runway and gently rotates skyward.

"Rolling left and rolling," Riggs sings out as the diamond formation soars overhead and the two solos line up for an opposing inverted pass. From the communication trailer, Pritchett tells Number One and the solos how close their flight paths are to the mark. "They know when they're off," he says, squinting at the expansive blue stage and taking notes. "I don't know how they can tell," says a technician videotaping the performance for a later critique. "I'm on the ground, and *I* can't see any errors." Master Sergeant Don Beard is counting the seconds between each maneuver, noting on a clipboard edged by three stopwatches precisely when the smoke systems are turned on and off.

In the VIP seats, squadron alumni critique the performance.

"That loop didn't look quite round."

"Timing could have been better."

"The wind's screwing up the smoke trails today."

The rest of the audience loves it all. They cringe at the opposing passes and scream in delight when Number Five barrels in unannounced at 150 feet doing Mach 0.94, and when the 35-minute performance is over, no one leaves. They stay for the closing march-down and the chance to get close to a Thunderbird or his airplane.

From time to time, Congress calls upon the Department of Defense to justify the existence of its military demonstration teams and the Thunderbirds' annual $1.2 million budget. "They want to know if they're getting their money's worth," Savko says. "We take them to a show and tell them to watch the crowd." As the engines whine down, the canopies open and helmets are removed—all on cue. People cheer, applaud, and wave flags, jackets, and inflatable F-16s. " 'Talk to *them*,' we tell the brass. 'Find out what they think. Then tell us if we're worth the money.' "

After the crowd disperses, the second shift wipes down the airplanes for the night. The first shift hits the showers, a laundromat, and a hotel that's agreed to cash personal checks. The pilots climb into a van and head for the little franks and chips at the officers' club.

Down to the Sea with Satellites

High above the Earth, satellites are making the ocean a less lonely place.

COMSAT

A mushroom-shaped antenna lets a ship's crew reach out and touch someone.

by Hale Montgomery

Passengers were already filling the 800-seat lounge aboard the liner *Queen Elizabeth II* as the ship's stewards hurried to finish erecting a large screen in the front of the room. Voices rose in an expectant buzz above the comforting background sound of the ship's engines.

High above the ship's deck, a brand-new antenna sat atop a stubby steel mast. With its white fiberglass dome, the antenna looked like a golf ball teed up for a giant.

On that January Sunday the ship was sailing southward in the Pacific, about 100 miles west of the Peruvian coast. The liner cruised at a steady 25 knots, no contest for the first faint satellite signals, moving at light speed, that overtook her. Relayed by a maritime satellite, collected by the dish-like antenna inside the white dome, and piped below to the lounge, the signals brought Super Bowl XX from New Orleans to the *QE II*, live and in color.

The success of the 1986 broadcast was far more significant than the outcome of the game. Sponsored by the Communications Satellite Corporation (Comsat), it was a convincing demonstration of how Space Age technology is changing communications at sea.

What makes the change possible is a global communications system, operated by the International Maritime Satellite Organization (Inmarsat), that has grown steadily since the first maritime satellite was placed above the mid-Atlantic over a decade ago. Attesting to the system's success are its more than 5,000 customers, including cargo ships, oil tankers, giant drilling rigs, luxury passenger liners, fishing boats, ice breakers, bulk carriers, yachts, ocean-going tugs, and even several trans-oceanic balloon adventurists. The customers using satellite communications increase by about 100 per month and could reach 10,000 by 1990.

Inmarsat, headquartered in London, is a cooperative venture of 48 countries; its director general, Swedish-born engineer Olof Lundberg, likens it to a not-for-profit corporation. Both the United States and the Soviet Union belong, making Inmarsat the only satellite business group in the world in which both superpowers participate.

Like most commercial space communications businesses today, Inmarsat's principal assets are literally out of sight, 22,300 miles up in geostationary orbits over the Equator. Nine satellites—three each over the Atlantic, Pacific, and Indian Oceans—act as radio relay towers for transmissions from the ground. On land, 17 coastal stations, two operated by Comsat in the United States, tie the system to existing terrestrial networks.

To maintain its momentum, Inmarsat has embarked on a $160 million program to purchase three second-generation satellites to replace three now in orbit. The organization hopes to start using these satellites next year to reach a new market: commercial aircraft flying transoceanic routes (see "The Missing Link," page 91).

Conspicuously mounted, usually high above the bridge for best reception, the white-domed antennas have come to indicate upward mobility on the high seas. One yacht owner wanted satellite service so he could trade in commodities while on a round-the-world idyll. For others, privacy is the goal, particularly at sea, where the alternative, marine radio, is the equivalent of party-line phone service.

For centuries, when a ship passed over the horizon it was effectively cut off from contact with land. Marconi's wireless radio, introduced at the turn of this century, was the first major improvement in marine communications. Radio technology since then has advanced, but even 11 years ago radiotelephony and radiotelegraphy, subject to the vagaries of medium- and high-frequency radio, were the only communications technologies available at sea.

The seeds for change were planted in 1972, the year the U.S. Navy found itself in a communications fix. LES-6 and TacSat-1, two experimental satellites the Navy used to communicate with its fleet, were due to be replaced, and the launching of the next generation of satellites had been delayed. When TacSat-1 failed in December 1972, the Navy desperately needed to start installing a new satellite system.

Enter Comsat. "We had a small group then called the Domestic and Aeronautical Systems Project Office," recalls Edward J. Martin, now Comsat vice president for technology management. Borrowing from earlier designs, the group adapted aeronautical satellites for maritime use. After submitting an unsolicited proposal to the Navy, the company won a two-year contract in March 1973 to outfit a new system.

What Comsat proposed was a hybrid satellite with channels at military frequencies for the Navy plus channels at commercial maritime frequencies for the shipping industry. "It's very unlikely anybody would have started maritime satellite communications then if they couldn't have provided a hybrid service," says John L. Martin Jr., a former

Even hidden in an Alaskan fjord, a seismic survey vessel can communicate with its home office.

COMSAT

vice president of Comsat General, the Comsat subsidiary responsible for operating the maritime system. "Alone—either maritime *or* the Navy—there just wasn't that big a market."

At first the Navy was hesitant about leasing—not buying—its communications hardware, but finally it agreed to the deal. The biggest question for Comsat concerned the shipping market: Would it bite? "Comsat really wanted to start [a new] commercial service . . . but it faced a Catch-22 situation," says Albert D. Wheelon, president of the Space and Communications Group at Hughes Aircraft Company, which eventually built the satellites. Shipowners wouldn't equip their ships with expensive terminals (then about $65,000) until a working satellite was in place, and Comsat needed a customer base before it established a satellite system. Comsat calculated that with a hybrid system, Navy leasing revenues from two years of two-ocean coverage would meet costs during the early years. If all went according to plan, revenues from a steadily growing shipping market would cover the subsequent years of the satellite's five-year lifetime, after the Navy had moved on to its own system.

On February 19, 1976, a $20 million satellite, nestled in the nose of a Thor-Delta 2914 rocket, lifted off a launch pad at Cape Canaveral into a clear evening sky. After controllers confirmed that the second and third stages had fired on time, speeding the satellite into perpetual orbit, they passed around cigars. Officials of Comsat, which owned 86 percent of the venture along with other communications companies, were jubilant. President Ford sent a congratulatory message.

The Navy inelegantly called the new satellite "Gapfiller"; Comsat called it Marisat. The world's merchant marine industry tended to just ignore it.

On March 25, 1976, the first satellite, positioned in geostationary orbit over the mid-Atlantic, started providing full service to the Navy. But trouble began brewing in the metallic guts of the spinning, drum-shaped satellite: the craft started to produce mysterious random variations in the civilian channels' signal strength.

Circuitry sleuths quickly pinpointed the culprit—a tuning filter called a triplexer. By opening up a similar filter on a plant workbench, engineers discovered minute scraps of metal, apparently created by the threading of a screw hole. In the weightlessness of space, the particles had floated into a narrow passageway in the triplexer and were randomly blocking signals through it. To dislodge the particles, ground control wobbled the spacecraft and shook them aside. "We called it the Cool Whip maneuver," says John Martin.

With that problem solved, commercial services for the Atlantic started in July. After the second and third Marisat satellites went into space without a hitch late in 1976, the system provided global coverage, although initially only the Navy had ground stations that could use the Indian Ocean satellite.

When commercial service began, Marisat's entire global clientele numbered only 20 ship customers. On July 9, 1976, *Deep Sea Explorer,* a small exploration vessel doing seismic surveys off Madagascar, received Marisat's first pay call, from her home office in Bartlesville, Oklahoma. Colin Wilkinson, then director of deep-sea exploration at Phillips Petroleum, remembers, "We needed to stay in touch daily. The call was what we call the morning report." The message may have lacked the drama of Alexander Graham Bell's "Mr. Watson, come here, I need you," but it did manage to alert the crew to avoid a port in Madagascar, where authorities would have impounded the ship because of an earlier dispute with the expedition's contractor.

The maritime world slowly began to take notice. Several research institutes began to investigate ways of computerizing sea operations, using Marisat to link ships with computer centers ashore. Others started a daily telex news service for ships or sent test transmissions of facsimile waybills.

Compared to conventional maritime radio, satellite communications proved quite clear—sometimes deceptively so. In 1977, while the containership *Lash Turkiye* was sailing in 30-foot seas off Bermuda, a seaman slipped off a ladder and was injured. Captain Harry Parker used the Marisat phone to call the U.S. Public Health Service hospital on Staten Island for advice. The hospital operator, after taking down the essentials, asked for the local address of the ship. "Nine hundred miles south of Bermuda," replied Parker. Again she asked. Again Parker answered, "Nine hundred miles off Bermuda." "I've heard all that," the operator snapped. "Just tell me where to send the ambulance."

The number of Marisat terminals increased, but not in an overwhelming wave: only 34 by the end of 1976, 92 by 1977, and 166 by 1978. Japan, meanwhile, built a coastal station at Yamaguchi, the first station outside the United States. That opened the Indian Ocean area to commercial Marisat communications in late 1978, tying the system's global string.

In 1979: 293 terminals and counting. One of them, fitted behind the bridge of the huge tanker *El Paso Paul Kayser,* turned out to be a lifesaver. On June 29, 1979, the tanker was carrying a cargo of cryogenically cooled liquified natural gas, a substance so combustible that the crewmen aboard received special pay. That night the unthinkable happened: *El Paso Paul Kayser* ran aground in the heavily traveled Strait of Gibraltar. In a dramatic rescue operation, the hazardous cargo was painstakingly transferred to a sister ship. For days, often three to four hours at a stretch, salvage teams kept the Marisat terminal on, exchanging telex and telephone messages with offices in Houston and receiving critical instructions and technical data from experts ashore. "Personally, I kissed the thing each morning," F. E. Schumaker, the ship's master, said afterwards.

Nevertheless, Marisat initially made

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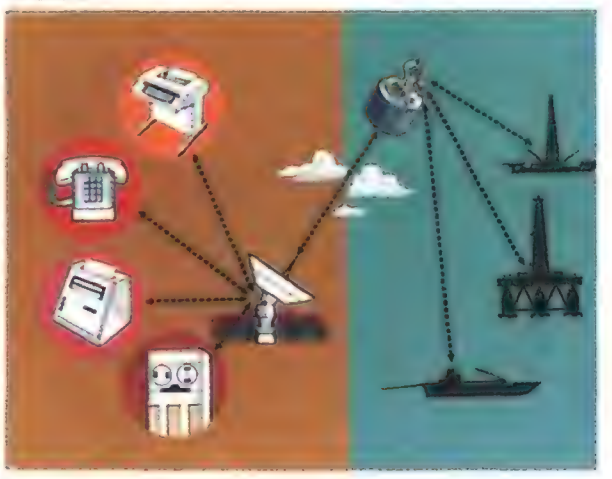

Functioning as relay stations, satellites allow users access to a variety of communications technologies.

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An Inmarsat terminal aboard the Calypso *has buoyed Jacques Cousteau's studies of the sea.*

Crews of small boats on the big sea are finding satellites useful. In a pinch they can even save lives.

COMSAT

The construction barge Narwhal *uses maritime satellites. Other users range from oil rigs to ice breakers.*

COMSAT

little more than a ripple in shipping company boardrooms in the United States and Europe. According to John A. Johnson, former president of Comsat General, "In the early years there was a decided lack of enthusiasm by maritime interests, particularly abroad. There was a lot of political foot-dragging, at least until some of the countries developed an ownership interest. It was difficult to sell even to U.S. shipping interests. They were very conservative."

The customer base, however, continued to build. In 1980, 542 terminals were in use; a year later, 968. But other nations grew wary of what they saw as the United States' dominance of maritime satellite technology. The establishment of the international cooperative Inmarsat, a venture under study for years by the United Nations' International Maritime Consultative Organization, opened up a way for other nations to gain a share in the future.

On February 1, 1982, operational control passed from Marisat to Inmarsat, a transition endorsed by the United States, which held the largest interest in the new organization. The commercial capacity of the three Marisat satellites was leased to Inmarsat to form its first space system, with Comsat functioning as the U.S. representative in the group. Besides the Marisat system, Inmarsat would also use satellites from the international Intelsat and European Marecs systems.

Comsat's original forecasts of commercial revenue, made in 1973 to the Federal Communications Commission, eventually turned out surprisingly accurate, but for many of the wrong reasons. While the number of ship terminals fell short of predictions, the average communications revenue per ship exceeded forecasts. A booming offshore oil industry, spurred by the oil embargo and OPEC price increases in the 1970s, accounted for much of the revenues.

Today, Inmarsat is looking at another market—aviation—that by itself has relatively modest international communications requirements. But tucked in with maritime services on the same satellites, it adds enough market mass to be feasible. Inmarsat's director general sees maritime and aeronautical satellite services as only part of a greater mobile communications system. "In the next ten years there may be other mobile satellite systems in addition to that operated by Inmarsat," Olof Lundberg says. He refers to current developments in aviation and in mobile land satellite systems that will provide service to trucks, trains, and even people with hand-held or backpack units. "The ultimate goal," he says, "should be to enable the user to make or receive a call no matter where he or she is—on the ocean, in the air, or on the land."

The Missing Link

Since the mid-1960s, studies done by the aviation industry have concluded that satellite services for civil aviation, although expensive, are technically feasible and potentially beneficial. But even today, oceanic air traffic control still relies heavily on conventional radio communications.

The need for something better is particularly acute on peak days, when the North Atlantic air routes serve some 500 flights, with a minimum separation between aircraft of 60 nautical miles laterally, 2,000 feet in altitude, and about 10 minutes (about 80 miles) ahead and behind one another. Each pilot, of course, wants the track with the best winds and weather, but changing altitude to seek better conditions is dangerous if the precise position of other aircraft isn't known. Unfortunately, there is no traffic control radar coverage at sea, and airplanes in transoceanic airspace report their positions by radio only about once an hour, unless conditions require more frequent updates.

With satellite communications, controllers could get routine position reports from aircraft in transoceanic flight every five minutes, even every few seconds when necessary. The Federal Aviation Administration calls the new service "pseudo-radar" because its surveillance power is nearly equivalent to that of land-based radar. The technology would dramatically change oceanic flying: separations could be reduced and more airplanes could fit into favorable tracks. Some feel the tragedy of KAL 007, the off-route Korean jetliner shot down by Soviet fighters in September 1983, might have been avoided if better position information and communications had been available.

Before satellite communications could be developed for air traffic control, the many countries involved would have to agree on standards for the three components of an air traffic control system: communications, navigation, and surveillance. The ideal plan would set international standards for a single integrated system that could handle air traffic control, airline communications, and even passenger communications.

Airlines also want to use satellites for engine monitoring, dispatch information, weather reports, crew change orders, and a host of other housekeeping chores, which would help boost the bottom line. The airlines could also make some money by providing in-flight passenger phone service.

Arinc (Aeronautical Radio, Inc.), which operates a private communications system serving the airlines, has proposed an industry-owned satellite system for the Atlantic, Pacific, and United States that it claims could be operating by next year. Each airliner using it would pay a minimum of about $87 per day, a cost that could perhaps be recovered from the revenue produced by passenger calls.

Arinc is not alone: the skies are crowded with businesses competing to provide satellite services to aviation. In the United States prospective purveyors include Airfone, Geostar, and some of the 12 companies recently given preliminary authority by the Federal Communications Commission to provide satellite service. Comsat Corp. and other companies would like to serve the airlines through the Inmarsat global system, starting perhaps in 1989; the U.S.S.R., Japan, and Europe have their own aeronautical satellite systems under development.

The cost of a global satellite system for aviation, not including the aircraft avionics (about $35,000 per airplane) or ground equipment, has been estimated at $5 billion, about the cost of a major new airport. So far, that doesn't seem to be stopping anyone. At a Congressional hearing held last fall, Siegbert Poritzky, director of Systems Studies and Cooperative Programs at the Federal Aviation Administration, predicted, "Before 1990 we will begin to see satellite communications services over the oceans."

—Hale Montgomery

Leapin' Rockets!

With a twist of motorcycle-like grips, rocket belt users were off and flying—for 21 seconds.

Mark McDonald

Buck Rogers was in trouble. Again.

The 25th century's greatest hero had landed in a seemingly innocent meadow. But all was not as it appeared. Suddenly the grassy field began to close over our hero like a huge Venus' flytrap.

"Quick! Turn on your rocket belt!" thought Nelson Tyler, a boy listening to the Buck Rogers radio show. *"Turn on your rocket belt!"*

Buck did. And young Nelson decided then and there, as he rode in the back of his father's Packard through Los Angeles' Griffith Park, that one day he would have a rocket belt of his own.

The dream was probably shared by hundreds of other young radio listeners during the 1930s. Imagine a free flight through the skies, propelled by nothing more than a rocket backpack! Tyler, however, actually made his dream come true, thanks to ingenuity, research, and a Bell Aerosystems engineer named Wendell Moore, who yanked the rocket belt from the fantasy realm in 1961.

A native of Canton, Ohio, Moore was the quintessential 1950s engineer—Eisenhower-era crew cut, horn-rimmed glasses, and bow tie. In case of late-night brainstorms, Moore even had a drawing board in his bedroom.

Soon after joining Bell in Buffalo, New York, in 1945, Moore had worked on the X-1B rocket plane, a winged bullet that used small thrusters to complement its control surfaces in the thin air at high altitudes. This control system ran on hydrogen peroxide, the chemically unstable substance that can turn brunettes into blondes or, when put in contact with a catalytic agent like silver, rapidly decompose into steam. When directed out a nozzle, that steam provides powerful thrust. Why not, Moore reasoned, create a peroxide backpack that would literally send its wearer flying?

Armed with a meager $150,000 contract from the U.S. Army Transportation Research Command, Moore and his Bell team set to work turning a dream into reality with spare parts. They used standard oxygen breathing bottles for the fuel tanks and spare components from Mercury spacecraft attitude jets to

construct the propulsion system.

The finished apparatus, which the Army romantically called the Small Rocket Lift Device, used highly pressurized nitrogen to force the 90-percent-pure peroxide fuel over silver-coated catalytic screens. The pilot was attached to this rocket by a form-fitting fiberglass corset that distributed most of the pack's fully fueled 120-pound weight to the hips. Throttle and yaw were controlled by motorcycle-type rotating grips. To move forward or backward, the pilot would merely have to lean to redirect the nozzles' thrust.

Unfortunately, the rocket belt could carry only enough fuel for 21 seconds of flight, and a vibrating device had to be installed on the back of the crash helmet to warn the pilot when it was time to get back to earth.

Moore first tested the belt while dangling from cables and tied to ropes held by straining volunteers. Even attached to a tether, flying the peroxide belt was difficult. The human body was not designed for flying, and a simple movement of the legs could easily create an uncontrollable pendulum motion. Moore himself broke his knee when his tether snapped and he fell onto the test hangar's concrete floor. After that, Bell employee Harold Graham took over the pilot's duty.

On April 20, 1961, Graham walked onto a field on the Bell grounds wearing a rubber flight suit and a cumbersome backpack with tubes, tanks, and two nozzles sticking out from the sides. He slowly rotated one of the pack's control grips, and the rockets screamed to life. Almost instantly Graham was enveloped in a thick white cloud as the steam cooled in the morning air. When he emerged into view, he was hovering slightly above the ground: the world's first free-flying rocket man. After 13 seconds he landed, having traveled a less-than-whopping 112 feet—8 feet less than the Wrights' first flight.

In 1961 America was entering the Tang Decade. That May, John F. Kennedy put the space race into high gear by aiming to place a man on the moon before 1970. On the New Frontier, rocket belts seemed as inevitable as Teflon. Commuters could fly to work; policemen could swoop from the skies to apprehend evil-doers. And camouflage-clad rocket soldiers could soar over forests, rivers, and even minefields to make the world safe for democracy.

In 1964 19-year-old William Suitor joined Bell. He had known Moore since childhood, and the engineer had asked him to fly the rocket belt and show the Army that a person with no flying experience could quickly master the device. But the military wasn't thrilled by the heavy, howling rocket belt and its 21-second flight time. "It was hard attempting to sell it to the military," says Robert Courter, a Korean War pilot who left his farm equipment company to become another rocket belt flier for Bell. "It just wasn't practical. It had a powerful fuel that was not compatible to field conditions."

But Bell—and Moore—persevered, trying various mutations of the rocket belt concept, including a rocket chair, rocket pogo, and even a two-man rocket pogo. "Wendell was insistent on using rocket fuel," recalls A. J. Feeney, at the time manager of special projects for Bell. "I don't know if he was enamored of Buck Rogers or what, but he was determined to use rocket fuel." It became obvious that an air-breathing engine was the only way to take advantage of the rocket belt concept.

Moore and his team went back to work on a new belt, with sponsorship from the defense department's Advanced Research Projects Agency. First they contracted with Williams Research Corporation, a Walled Lake, Michigan firm, to construct a tiny turbojet engine that could lift a person into the sky and keep him there. Williams delivered the WR-19. Powered by jet fuel and only two feet long, it required counter-rotating fans to remove torque effects that would have had a jet belt pilot spinning crazily across the skies. It was a neat piece of work.

On April 7, 1969, at Fort Myer, outside Washington, D.C., Robert Courter took the jet belt up for its first free flight. With a twist of the throttle and a

by Tom Huntington

Thirty years ago visionaries predicted nobody would leave home without one.

roar of the engine, he was airborne, hovering over the heads of his observers. Later flights with the jet belt, all flown by Courter, lasted up to seven minutes and reached altitudes of around 70 feet. But the belt was still loud, and it was so heavy it had to be supported on a stand until the flier throttled up.

On May 29, 1969, Wendell Moore died of a heart attack while working at his bedroom drawing board. He was 51. That day Bell made the first public announcement of the jet belt's flight.

The military decided to pass on the jet belt, preferring to use the WR-19 engine for propelling cruise missiles.

Meanwhile, the technologically backward peroxide belt had become a success. When Feeney's Bell superiors had told him to either market the device or kill it, Feeney chose the former. "I put Bell into show business and we barnstormed all over the world—for money," he says. Bill Suitor flew one of the rocket belts for the movie *Thunderball*, disguised as Sean Connery. The peroxide belt also made appearances in everything from the television program "Lost in Space" to commercials for Keds sneakers. At the

Bell Aerospace

The drawbacks to the jet belts soon became apparent. Size, weight, and noise did them in.

Dean Conger © National Geographic Society

Wendell Moore sought to put Everyman into the space age, but only a few people ever flew one of his rockets.

New York World's Fair in 1964, it played a part in the "Wonder World" musical extravaganza.

One person who had been watching the rocket belt with interest was Nelson Tyler. Now grown up, he had become an aerial cameraman and the inventor of a helicopter camera mount widely used in the movie industry. During the 1965 Christmas season Bill Suitor was in Disneyland, flying the rocket belt for Bell. "There were a lot of curiosity seekers," Suitor recalls, "but I remember one man who was almost to the point of being obnoxious. He was there every day and had a friend snapping pictures from every conceivable angle. He insisted on taking pictures with his arm around me, and I didn't know it, but he had a little scale in his hand." Bill Suitor, meet Nelson Tyler.

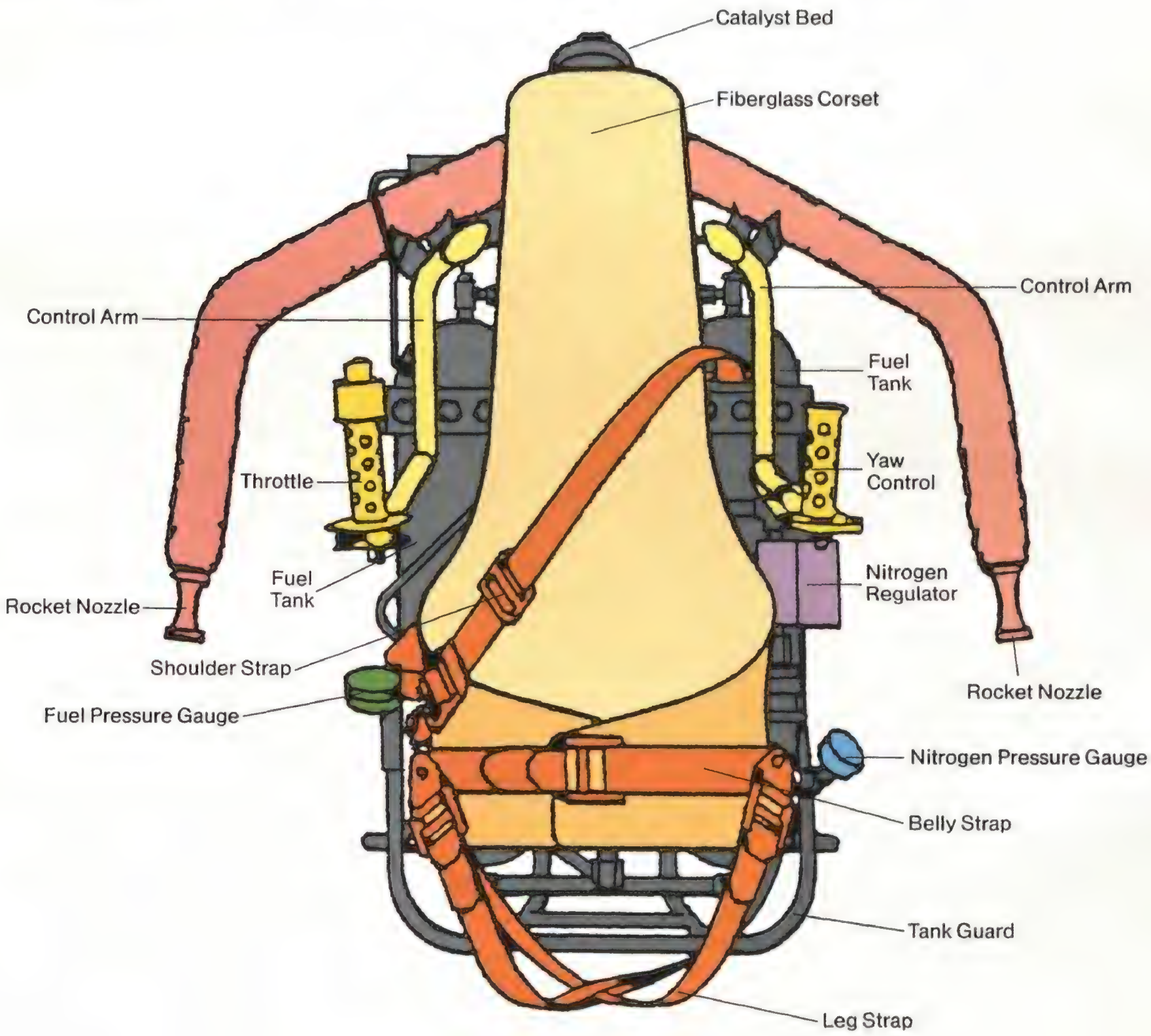
Williams International

After trying it first in the jet belt, Williams International put the WR-19 fanjet in a flying platform.

With the Disneyland photos blown up to life-size and technical books with detailed diagrams of a peroxide system, Tyler built a rocket belt like Moore's. He estimates the cost at $15,000, which included a $3,500 throttle valve and $1,500 worth of silver. (When a movie company built a wooden mockup of Tyler's belt this year, they spent $16,000.)

Anatomy of a hydrogen peroxide rocket belt

William Suitor



"It was purely a hobby," Tyler says. "There was no way to make money out of it that I saw." He got some help from Suitor, who left Bell in 1970 to fly the rocket belt for its builder. Tyler himself flew the belt commercially only once, for a Canadian Club ad advising that the best thing after a rocket belt flight was a stiff belt of a different kind.

Today Tyler, who looks like a more stable and tanned version of the professor in *Back to the Future*, works out of his headquarters in Van Nuys, California. His many projects include camera mounts (both aerial and aquatic), the Wetbike (like a snowmobile for the water), and even a blimp ("Bigger than the Goodyear Blimp," he says proudly, although it has been in mothballs since suffering damage during a flight). The walls at Tyler Camera Systems are covered with posters from *Blue Thunder*, *Apocalypse Now*, *Raiders of the Lost Ark*, and other films that have employed the Tyler Camera Mount. The director's "hanging seat" from the movie *The Stunt Man* dangles from the ceiling in the main work area. In the back is the office for American Flying Belt Corporation, its walls decorated with blown-up panels from a comic book featuring men flying with rocket belts.

Tyler's belt went commercial in a big way in 1984, after Bill Suitor flew the device for a capacity crowd at the Olympics' opening ceremonies. "Everybody was knocking on our door," Tyler says. "Every week we were doing something." Hollywood stuntman Kinnie Gibson took over the flying chores from Bill Suitor, who retired after his Olympics flight. Gibson kept up a busy itinerary: flying for "The A Team," doing publicity for a hotel in Orlando, rocketing around Europe. One flight in Egypt ended abruptly when moisture clogged the feed lines as Gibson circled the head of the Sphinx.

The pilots agree, though, that when things go right, there's nothing like flying a rocket belt. "It's totally controllable," says Tyler. "You can fly sideways, backwards. Unlike a helicopter or an airplane, you're not using any kind of aerodynamic surface. It's not affected by wind. You could put a dime out and land on it."

"Once you get so you relax with it, it gets to become second nature, like riding a bicycle," says Suitor, who has made over 2,000 rocket belt flights for Bell Aerosystems and Tyler. "When you strap the belt to your back you become part of it and it becomes part of you. But you only have 21 seconds—there's always that time element."

Courtesy Nelson Tyler

Once a wide-eyed fan of Buck Rogers, Nelson Tyler grew up to soar like his 25th century hero.

Of his 2,000 flights strapped to a rocket, Bill Suitor's 1984 Olympics flyover captured the most attention.

Another drawback is the fuel, which is expensive and too dangerous to ship by airplane. Tyler recalls one time when dockworkers unloaded a leaking peroxide barrel, turned it on its side, and rolled it away, leaving a smoking trail. "They just parked the stuff and we couldn't get it out because nobody wanted to move it," Tyler says. "That's a real hassle."

Tyler recently sold his peroxide belt to the Swedish amusement park Tivoli Gardens ("They offered me a lot of money," he says simply), and he now dreams that a new design of his will bring flying belts to the public. Called the Pulse Belt, Tyler's machine will employ small but powerful pulse jets.

One of the simplest forms of jet propulsion, the pulse jet powered the notorious German V-1 "buzz bomb" in World War II. Tyler envisions running a pulse belt on ordinary gasoline, preferably unleaded.

He has calculated that for a belt with only two pulse jets, each engine would have to be eight feet long to provide sufficient power to lift a person. So Tyler is thinking now of using 16 smaller engines, 8 on each side, which would

provide reassuring redundancy.

Some people may find the prospect of flying through the skies attached to 16 roaring, gas-powered pulse jets a tad unnerving, especially since a pulse jet is usually an all-or-nothing proposition: either it's running at full power or it's off. But Tyler likes the pulse jet because of its few moving parts, and, inveterate tinkerer that he is, he thinks he can rig up some form of variable throttle.

Lack of time and money has slowed the pulse belt project—Tyler estimates that building and flying a prototype would cost $250,000. Still, he has been working on two new engines. "One ran for 20 seconds, burping and spitting and actually running," he says.

"Our ultimate goal," explains Tyler, "is to provide jet belts for people to buy. We're talking strictly stuff like dirt-bike motorcycles, drag boats, drag cars, hang gliders, ultralights, that kind of stuff. Just for thrills."

While he waits for the opportunity to finish a pulse belt prototype, his teenage son Chris is working on a radio-controlled mini-rocket belt, which is strapped to a toy figure of wrestler Hulk Hogan. Unfortunately, Hogan is too much of a hulk for the toy fan-powered belt. Perhaps, with military funding, G.I. Joe could be persuaded to fly.

Forward Motion

Fantastic visions of interstellar propulsion move physicist-author Robert Forward to think beyond the stars.

by Eugene F. Mallove

When the first robotic star probe speeds out of our solar system sometime in the 21st century, it will be propelled, at least in part, by Robert Forward's imagination. Whether that probe is powered by antimatter, lasers, or microwaves, it will owe a debt to Forward, a promoter of cosmic travel who is dedicated to convincing solar system-bound skeptics.

The outspoken physicist has devoted half of his 54 years to inventing ways of traveling across the forbidding interstellar gulf, and he's come up with some intriguing alternatives to rocketry as we know it. Forward thinks the first star probes will be giant ultrathin sails propelled by beams of light or microwaves.

He knows he may never see his visions materialize. "I'm quite willing," he says, "to look at a lot of things that others may not know the answers to till after I'm dead. It bothers lots of people. They want to limit their view to those things they can decide while they're alive." But while he does not expect that he will ever travel in space, he believes it's inevitable—"built into our genes"—that Earthlings will migrate to other stellar systems and spread throughout the universe.

Forward is internationally known in space circles as the leader of a small conspiracy of scientists and engineers who audaciously champion star flight when the planets of our own solar system are far from fully explored. In 1985, for example, at a Harvard symposium on the search for extraterrestrial intelligence, Forward argued with great force and aplomb that star probes could soon become valuable tools in the search for extraterrestrials.

Assuming that ETs don't contact us first, Forward believes that visits to planets outside our solar system may be the only way to find out about them. He concedes that the current practice of using radio telescopes to search for signals from extraterrestrials is the best first step. "But if after 50 years we haven't heard anything," he says, "then we've got to go out, and that will be about the same time we are ready for interstellar flight."

And where are all the aliens who should have gotten to *us* by now with *their* advanced technology? Forward favors the "zoo" hypothesis: ETs have designated Earth a preserve off-limits to extraterrestrial interlopers.

Straightforward as he is about his quest for the stars, Robert Forward is a complex and iridescent man who could easily pass as a character in one of his own science fiction novels. He invariably wears a white bow tie with his favorite gray suit to avoid a clash with one of his outlandish multicolored homemade vests, a trademark that his wife Martha first bestowed in their days of student poverty. Appropriately, many of his vests display an air-and-space motif—birds, stars, clouds, rainbows. With a laugh that squeezes his shining eyes to slits, Forward explains, "In graduate school I was known as a very well dressed person, but most people didn't realize I had only one suit." He usually has about 15 vests on hand; his wife makes him five new ones a year, and "the old ones get retired as they shrink," he says dryly.

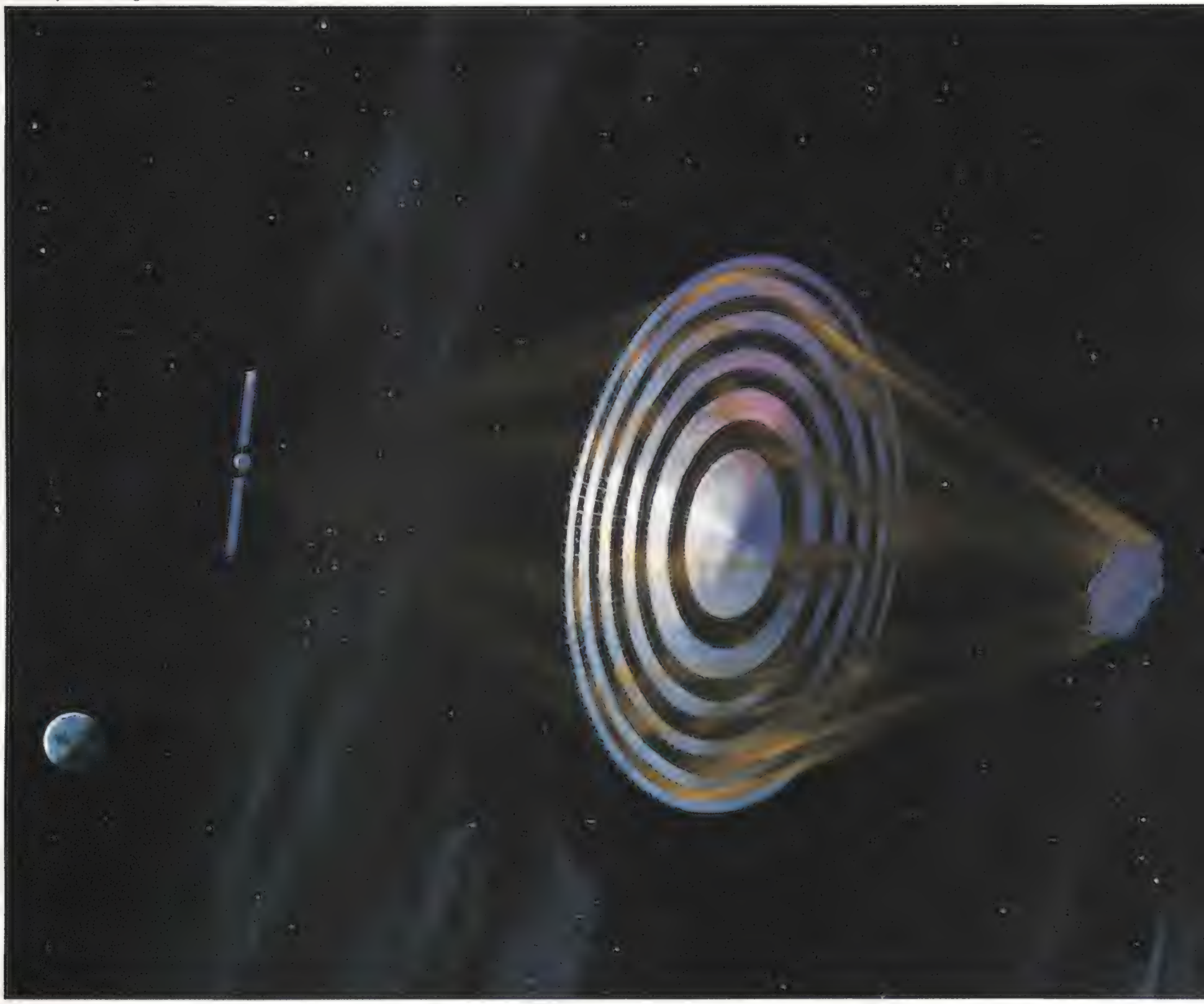
Forward can't remember a day when he didn't want to be a scientist. Neither of his parents was a scientist, but he says his high school teachers inspired him to plunge into math and physics and chemistry. Notwithstanding his puckish manner, he's been engaged in utterly serious scientific research all of his adult life. Currently, he is a senior scientist at Hughes Research Laboratories in Malibu, California. Nestled amid lush greenery overlooking the Pacific, this high-tech mecca (a branch of Hughes Aircraft Company) is where Theodore Maiman built the first working laser in 1960. Forward came to the lab in 1956 with a bachelor's degree in physics from the University of Maryland. Hughes paid his way through graduate school, and by 1965 Forward had earned his Ph.D. in gravitational physics.

During his grad school days, Forward worked with University of Maryland physics professor Joseph Weber on the first detector of gravity waves—ripples of gravitational force that Albert Einstein predicted are traveling through space-time at light speed. (Scientists theorize that gravity waves may be by-

Crackling with energy, Robert Forward plans to tackle a universe of new projects even in semi-retirement.

Dan Golden

Seichi Kiyohara for Hughes Research Laboratories



A satellite (left) could beam microwaves through a concentrator lens to propel a maser sail (right).

products of exploding stars called supernovas.) Forward gleefully notes that "my thesis is in the Smithsonian!" He means the one-ton aluminum cylinder that was the sensing element of the detector he and Weber built—it's on display in the Smithsonian's National Museum of American History, where "kids can sit on it and ride it like a horse."

Gravity has always fascinated Forward. Driving home one day in 1963, Forward was pondering the problem of how to generate gravity waves in the laboratory to test gravity wave detectors. In a flash of inspiration, he came up with an idea for something radically different. When he got home, he started writing up plans for a mass detector he called a gravity gradiometer. The National Aeronautics and Space Administration decided to fly one on an Apollo lunar mission, but the mission was canceled, and Forward went on to develop other versions of the instrument. The gradiometer era is over at Hughes, however. "Everybody that worked on the project except me is retired," says Forward. "It's gone."

In the early 1960s, Forward started promoting the concept of light-sailing through space, an outgrowth of the solar sail first proposed by Russian space flight pioneer Konstantin Tsiolkovsky in the 1920s. Forward suggested that an array of lasers in space, powered by solar energy, could propel a thin sail fast enough to move it out of the solar system. Probes propelled by chemical rockets would take thousands of years to reach the nearest stars, trillions of miles away; Forward's sailing spacecraft would get there in decades.

Forward's most recent variation of the laser sail idea is a maser sail he calls Starwisp—a half-pound spiderweb of wires measuring two-thirds of a mile across, sprinkled with microcircuits, and propelled by a 10-billion-watt beam of microwaves. The microwave energy

could come from a solar power satellite orbiting Earth, and "the microcircuits at each intersection of the Starwisp mesh would collect this energy using the wires in the mesh as microwave antennas," Forward explains. The microcircuits would also serve as sensors to gather data and transmit it back to Earth. Accelerating at 115 Gs to more than 20 percent of light speed in just a few days, Starwisp would take 21½ years to arrive at Alpha Centauri, which is 4.3 light-years (more than 25 trillion miles) away.

Forward is working on a more classic interstellar travel technique called antimatter annihilation propulsion. Forward consults for the Air Force Rocket Propulsion Laboratory at Edwards Air Force Base in Southern California on futuristic space propulsion—his one-man company is aptly named Forward Unlimited—and as a government contractor he's dug deeply into the quixotic realm of antimatter, deep enough to get antimatter annihilation propulsion on the U.S. Air Force Systems Command's list of "new technologies with exceptional promise."

Rockets running on antimatter, the most powerful fuel imaginable, have been a staple of science fiction stories for years. In contrast to nuclear fission and fusion reactions, which convert only a small fraction of fuel to energy, antimatter-matter reactions can yield 100 percent energy conversion. Forward thinks a beamed propulsion method such as Starwisp's is the best way to go to the stars, but this hasn't kept him from thoroughly studying antimatter, specifically antiprotons, as spacecraft fuel. He's concluded that antiproton annihilation propulsion might be an extremely efficient means of traveling *within* the solar system.

When antiprotons—more precisely, the nuclei of antihydrogen, which are produced in nuclear accelerators—collide with protons, the subatomic particles destroy each other, breaking up into short-lived particles called pions, one-third neutral and two-thirds charged. In a matter of attoseconds (quintillionths of a second), the neutral pions convert to gamma rays. But the charged pions do not convert to gamma rays; they endure for some billionths of a second before converting to other types of particles, and Forward says this is time enough to channel the charged pions through a rocket nozzle made of magnetic fields to generate thrust.

The biggest stumbling block to using antimatter for fuel has been generating, collecting, and storing it—freezing it into minute crystals of antihydrogen ice suspended in a vacuum. But last fall, physicists working at the large nuclear accelerator at the Center for European Nuclear Research (CERN) in Switzerland succeeded in cooling and trapping a small quantity of antimatter for the first time.

Storing antimatter fuel is not the only thorny problem challenging Forward. Over the next 30 or 40 years, he says, it may be possible to increase the current "abysmally low" antimatter collection efficiency of nuclear accelerators 100,000-fold, solve storage problems, and produce antimatter fuel for $10 million per milligram. One milligram at $10 million could replace 20 tons of liquid oxygen-hydrogen, one of the most powerful chemical rocket fuels now in use. Twenty tons of chemical fuel would cost more than $100 million to place in low Earth orbit, Forward estimates.

While Forward has been up to his elbows in hard science over the last three decades, he's spent much of his time away from the lab writing science fiction novels about such curiosities as the cheela—intelligent creatures made of atomic nuclei. The nuclei of atoms that make up humans are surrounded by clouds of electrons that encompass a lot of empty space; cheela nuclei don't have electron clouds, so cheela are much denser than humans. "They're about the size of a sesame seed, but they weigh as much as we do," Forward explains. The cheela live on the surface of a pulsar (a dense, fast-spinning neutron star), and their culture evolves a million times faster than human civilization.

Neutron stars are certainly real, but most scientists are convinced that any extraterrestrial life is likely to involve chemical rather than nuclear reactions. Forward makes the fictional cheela seem real, however, and he supports his cast of characters with scientific explanations appended to his novels. Summarizing his unusual approach to fiction writing, he says, "I'm trying to make the frontiers of science and then write science fiction about them."

In his nonfiction writing, Forward is determined to be innovative and correct. However, the idea of star flight attracts kooks as well as serious visionaries, and Forward reviews most of the crackpot letters sent to Hughes by people claiming to have such wondrous things as perpetual motion machines and magic rockets. He acknowledges that most of the time the writers are self-deluded or mistaken (though he is well aware that less imaginative scientists may think he is no better). But in studying the crank mail he often finds an idea worth learning about, even though the reasoning behind it may be unsound—"Occasionally I will find a new way of looking at the universe."

Despite his energetic work pace, Forward has managed to blend his eclectic interests smoothly with family life, which includes four children. Since 1962, he and his wife have lived in the same unpretentious Oxnard, California home adorned with his surrealistic space paintings—relics of an abandoned hobby. But Forward is retiring from Hughes this year. He'll continue working with the Air Force Rocket Propulsion Laboratory, and he's looking for a new home on the West Coast. In addition, he's buying a home in Scotland—a place to write. Forward is working on a book about antimatter propulsion titled *Mirror Matter*, due out next year, and he plans to continue writing science fiction, taking a break every three or four novels to do some science writing.

Forward has a science book coming out this year called *Future Magic*. The title alludes to science fiction author Arthur C. Clarke's "third law," which states: "Any sufficiently advanced technology is indistinguishable from magic." The book covers virtually every aspect of far-out physics that Forward's roving mind has touched, from faster-than-light communication to the possible physical nature of "spirit." Regarding the latter, Forward says, "Some people think that you have to take God on faith. But that's not my general philosophy about anything."

Robert Forward is paving the way to 21st century space exploration, and it's certain that the future will move Forward to new thinking about old physics, Forward to the stars. ✈

Have Art, Will Travel

For some, space might serve as a combat zone. For others, it could be a vast mall of high-tech commerce, a science laboratory, or the way to adventure. For the French, it's all these things and more. With Gallic grandeur, they've declared space to be a gigantic *galerie des arts* just waiting for a show. With the same élan they've flaunted in the making of sauces, wines, and love, the French are taking command of space, planning to civilize the heavens in one exquisite stroke.

With any luck, in 1989 the night sky will display a ring of light measuring 16 miles around—about the size of Paris, naturally—swinging gracefully across the constellations every hour and a half. This inflatable *objet d'art*, designed to last for three years, will consist of 100 spheres of reflective plastic, each 20 feet across, ranged along a ring of plastic tubing.

An Ariane rocket will launch the sculpture packed in a one-cubic-meter box that will open in orbit and let the work of art balloon to city size 500 miles above Earth. Visible to *tout le monde* every night as it circles from pole to pole, the ring will reflect sunlight, looking to Earthlings like a moon-sized diamond necklace tossed into the sky.

This grand artistic endeavor is the product of a contest held by the Société Nouvelle d'Exploitation de la Tour Eiffel, which manages the Eiffel Tower as a tourist attraction for the city of Paris. The Tour Eiffel group decided that the best way to celebrate the centennial of the famous landmark would be to create an even more spectacular work of engineering and art.

And so last year Tour Eiffel invited creative sorts in 14 European countries to design "an Eiffel Tower in space." The sponsors asked for an orbiting project that would be visible all over the world, 100 percent peaceful and noncommercial, and an outstanding symbol of universal communication. From 99 entries, an international panel of judges selected the ring of light-struck spheres, the design of a group of French architects working with Jean-Pierre Pommereau, a scientist with

Illustrations by John L. Heinly

France's National Center for Scientific Research. The European Space Agency and France's National Center for Space Studies will help the project designers decide whether and how their project can really be launched. *Un projet sérieux.*

How fitting it will be to loft a monument into the airless reaches of space in salute to Alexandre Gustave Eiffel, the builder of bridges and towers who advanced the science of aerodynamics with his 1910 book *La Résistance de l'Air et l'Aviation.* But while the territory of space promises smooth sailing for the sculpture, this celestial Son of Eiffel may face resistance of another sort.

The project will cost only about $1.2 million, less than some Earthly necklaces. But technical problems may ground the ring of light. If they do, says Tour Eiffel president Bernard Rocher, the Tour Eiffel group will try to raise funds for the runner-up project, conceived by Christian Marchal, a physicist at the Paris Observatory, and artist Pierre Comte. They want to launch a 2,160-square-yard reflecting sail they say would appear in the sky as "a new star invented by man."

Stars are expensive, though; this one would cost $7.5 million. Surely money should be no obstacle for such an enlightened proposal—but trouble could materialize in the form of old-fashioned notions about tampering with nature.

The night sky with its gigantic constellations wheeling overhead has inspired lovers, mystics, storytellers, and philosophers for as long as humans have been on this planet. Contemplating the cosmos leads us outward to thoughts of permanence and infinity, inward to humble thoughts about the spark that makes us human. To interrupt our vision of the heavens, to upstage celestial workings, would be sacrilege, some will surely say.

Others may wonder how space art will affect tribal people whose myths, history, and religions are tied to stories of the stars. The gods, they might assume in panic, have truly gone crazy.

Stick-in-the-muds will insist that space should be left pristine. They should recall, however, the incomparable beauty of the satellite Echo, tracing a silent illuminated path across the sky, and the thrill it gave sky watchers. Why not give them something even more visible?

Some say that sending art into orbit is not a disruption of the natural order at all but simply a Space Age extension of the artist's traditional function. "From the ancient past, artists have formed images and dreams, fired the imagination, built structures of aspiration to give the world wings to fly and the vision to see new societies in the sky," asserts a manifesto drafted by a group of sky artists with the Massachusetts Institute of Technology's Center for Advanced Visual Studies.

No one will deny that art is uplifting, and the French work of art will lift billions of eyes toward space. Think of how many people spent hours searching the skies for a glimpse of Halley's comet last year. (And think of how many dollars they spent—on new viewing equipment and trips to the South Pacific). Countless thousands never saw it at all. Others glimpsed only a smudgy point of light and had to be satisfied with *that* as the great astronomical event of their lives. *Pouf.* The show was over.

But let's face it, most people don't go out and look at the stars. Most people couldn't find the huge and striking constellation of Orion if it waved its sword at them. And while we're at it, let's admit that the night sky can be boring. Most people don't get excited about watching the Big Dipper rise and set with robotic regularity, followed by the Constellation Whatever, over and over again, year in and year out, barely changed since Cro-Magnon times. The Frenchmen's space necklace should be welcome relief.

Galleries draw crowds these days by rotating exhibits—so why not send a traveling exhibit into space? Why not have a necklace of shining spheres sweeping through the constellations overhead? People are bound to get out and look—and as they do they'll notice all those constellations it passes. And once the ring of light has dropped out of orbit and burned up on the way to Earth, perhaps in a flashy final display, other works of space art will follow. Several could be up there at once, in different orbits, staging a changing light show on a heavenly scale hundreds of miles above the planet.

A gallery in space sounds grand. But the advent of space art does pose one mildly ominous threat. Outer space is wide-open territory for peaceful enterprises, and the folks at Tour Eiffel are concerned that some materialistic soul might take their lofty concept of art and twist it into tacky Times Square commercialism.

The cost of getting the new Eiffel Tower into space won't be any higher than what breweries spend routinely to advertise during televised football games. It may not be long before industry decides that space is the way to reach the whole world with commercials.

In fact, it almost happened just a couple of years ago. In 1985 Coca-Cola and Pepsi-Cola aggressively publicized their launching of zero-G soft drink cans on the space shuttle. It's not very likely that the many government agencies involved in approving space launchings would permit the orbiting of a billboard—but the concern is understandable.

The Tour Eiffel contest drew one entry—a German proposal, it was—suggesting the launching of a plastic disk that would rotate as it glided overhead, blinking out a noncommercial message in a sort of code. Once a method of universal communication is demonstrated in space, can advertising be far behind?

Well, as the French might say, it's all a matter of good taste.

—Jake Page

The Brick Moon

By the mid-19th century, science fiction had emerged as a literary genre, and writers as well known as Cyrano de Bergerac, Jonathan Swift, Nathaniel Hawthorne, and Mary Shelley had written fanciful stories with science fiction elements. In the 1860s a Frenchman named Jules Verne began fascinating readers with tales of submarines and moon shots, speculative stories that later proved to be surprisingly prescient.

Among Verne's American contemporaries was Edward Everett Hale, a prolific and popular author whose best known work was the short novel The Man Without a Country *(1863). While Hale was not primarily a fantasist, "The Brick Moon," serialized in* The Atlantic Monthly *in 1869, and its sequel, "Life in the Brick Moon," are often cited as the literary precursor to the concept of a manned space station.*

Hale's story is told by the narrator of The Man Without a Country, *Frederick Ingham, as a recollection of events that started 30 years before. His tale opens with the memory of a discussion in a Boston college classroom, in which Ingham and his fellow students discussed "this business of longitude." They noted that anyone in the northern hemisphere could determine latitude by the height of the North Star above the horizon but that there was no simple way to determine longitude.*

The latitude, which you have found, measures your distance north or south from the equator or the pole. To find your longitude, you want to find your distance east or west from the meridian of Greenwich. Now if any one would build a good tall tower at Greenwich, straight into the sky—say a hundred miles into the sky—of course if you and I were east or west of it, and could see it, we could tell how far east or west we were by measuring the apparent height of the tower above our horizon . . . .

But nobody will build any such tower at Greenwich, or elsewhere on that meridian, or on any meridian. You see that to be of use to the half the world nearest it, it would have to be so high that the diameter of the world would seem nothing in proportion. And then, for the other half of the world you would have to erect another tower as high on the other side. It was this difficulty that made Q. suggest the expedient of the Brick Moon . . . .

The plan was this: If from the surface of the earth, by a gigantic pea-shooter, you could shoot a pea upward from Greenwich, aimed northward as well as upward; if you drove it so fast and far that when its power of ascent was exhausted, and it began to fall, it should clear the earth, and pass outside the North Pole; if you had given it sufficient power to get it half round the earth without touching, that pea would clear the earth forever. It would continue to rotate above the North Pole, above the Feejee Island place, above the South Pole and Greenwich, forever, with the impulse with which it had first cleared our atmosphere and our attraction. If only we could see that pea as it revolved in that convenient orbit, then we could measure the longitude from that, as soon as we knew how high the orbit was.

"But a pea is so small!"

"Yes," said Q., "but we must make a large pea." Then we fell to work on plans for making the pea very large and very light. Large—that it might be seen far away by storm-tossed navigators: light—that it might be the easier blown four thousand and odd miles into the air; lest it should fall on the heads of the Greenlanders or the Patagonians; lest they should be injured and the world lose its new moon. But, of course, all this lath-and-plaster had to be given up. For the motion through the air would set fire to this moon just as it does to other aerolites, and all your lath-and-plaster would gather into a few white drops, which no Rosse telescope even could discern. "No," said Q. bravely, "at the least it must be very substantial. It must stand fire well, very well. Iron will not answer. It must be brick; we must have a Brick Moon!"

The enthusiastic students worked out a scheme to launch the moon by harnessing the energy generated by giant flywheels set in the middle of a stream. But when their budget revealed that "the brick alone would cost sixty thousand dollars," they quickly abandoned the project.

The idea was resurrected years later when one student made a fortune in railroad speculation. The classmates gathered again to search for a suitable site, one with a stream for the flywheel and a clay-like soil for making bricks. They found the ideal location at the foot of a certain Spoonwood Hill in mid-Maine, where they set up camp and got to work.

They planned the moon as follows:

Any section through any diameter looked like an immense rose-window, of six circles grouped round a seventh. In truth, each of these sections would reveal the existence of seven chambers in the moon—each a sphere itself—whose arches gave solidity to the whole; while yet, of the whole moon, the greater part was air. In all there were thirteen of these moonlets, if I am so to call them.

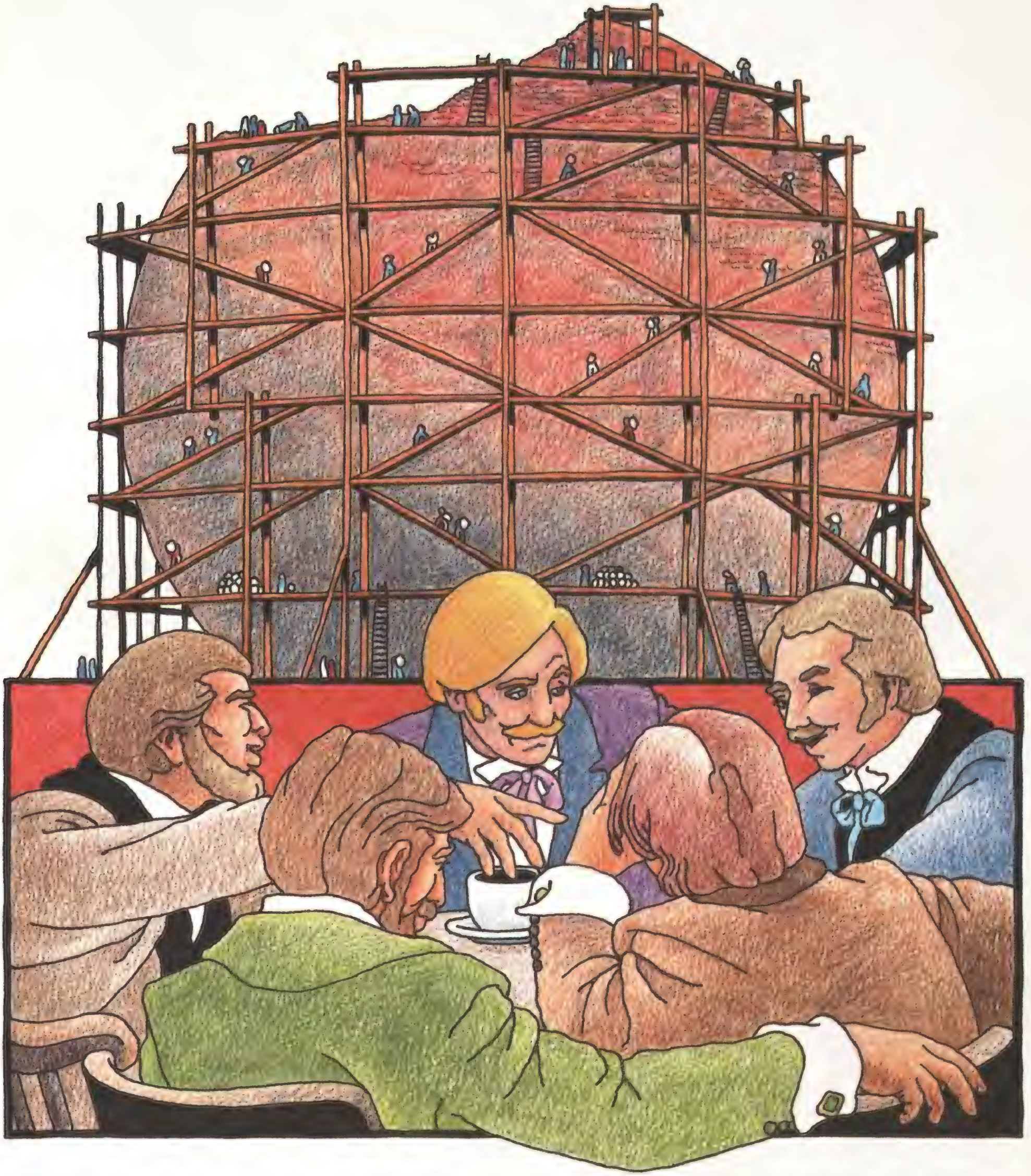
These moonlets were designated by the letters A through M.

At the start of winter, most of the moon's builders returned home, but 37 elected to stay behind. When the weather worsened, they moved into the shelter offered by the moon's completed sections.

One night, as the families slept inside it, the Brick Moon slipped free of its moorings and the flywheels hurled it into space.

When Ingham and his friends learned of the mishap, they feared that their colleagues had been incinerated as the moon hurtled through the atmosphere. For over a year they knew nothing about the moon's fate, until astronomical journals noted a new and peculiar asteroid. Once he knew where to look, Ingham was able to track the brick moon through a pair of opera glasses. But he still knew nothing about the fate of his friends. Eventually he arranged to use a powerful telescope to study the moon in greater detail.

Night came. I was "sole alone!" [Brick Moon] came, more than filled the field of



Illustrations by Max Karl Winkler

vision, of course; but for that I was ready. Heavens! how changed. Red no longer, but green as a meadow in the spring. Still I could see—black on the green—the large twenty-foot circles which I remembered so well, which broke the concave of the dome; and, on the upper edge—were these palm-trees? They were. No, they were hemlocks by their shape, and among them were moving to and fro—flies? Of course, I cannot see flies! But something is moving—coming, going. One, two, three, ten; there are more than thirty in all! They are men and women and their children!

Could it be possible? It was possible! Orcutt and Brannan and the rest of them had survived that giddy flight through the ether, and were going and coming on the surface of their own little world, bound to it by its own attraction and living by its own laws!

As I watched, I saw one of them leap from that surface. He passed wholly out of my field of vision, but in a minute, more or less, returned. Why not! Of course, the attraction of his world must be very small, while he retained the same power of muscle he had when he was here. They must be horribly crowded, I thought. No. They had three acres of surface, and there were thirty-seven of them. Not so much crowded as people are in Roxbury, not nearly so much as in Boston; and besides, these people are living underground, and have the whole of their surface for exercise.

I watched their every movement as they approached the edge and as they left it. Often they passed beyond it, so that I could see them no more. Often they sheltered themselves from that tropical sun beneath the trees. Think of living on a world where from the vertical heat of the hottest noon of the equator to the twilight of the poles is a walk of only fifty paces! What atmosphere they had, to temper and diffuse those rays, I could not then conjecture.

I knew that at half past ten they would pass into the inevitable eclipse which struck them every night at this period of their orbit, and must, I thought, be a luxury to them, as recalling old memories of night when they were on this world. As they approached the line of shadow, some fifteen minutes before it was due, I counted on the edge thirty-seven specks arranged evidently in order; and, at one moment, as by one signal, all thirty-seven jumped into the air—high jumps. Again they did it, and again. Then a low jump; then a high one. I caught the idea in a moment. They were telegraphing to our world, in the hope of an observer. Long leaps and short leaps—the long and short of Morse's Telegraph Alphabet—were communicating ideas. My paper and pencil had been of course before me. I jotted down the despatch, whose language I knew perfectly:

"Show 'I understand' on the Saw-Mill Flat."

"Show 'I understand' on the Saw-Mill Flat."

"Show 'I understand' on the Saw-Mill Flat."

By "I understand" they meant the responsive signal given, in all telegraphy, by an operator who has received and understood a message.

As soon as this exercise had been three times repeated, they proceeded in a solid body—much the most apparent object I had had until now—to Circle No. 3, and then evidently descended into the Moon.

The eclipse soon began, but I knew the Moon's path now, and followed the dusky, coppery spot without difficulty. At 1.33 it emerged, and in a very few moments I saw the solid column pass from Circle No. 3 again, deploy on the edge again, and repeat three times the signal:

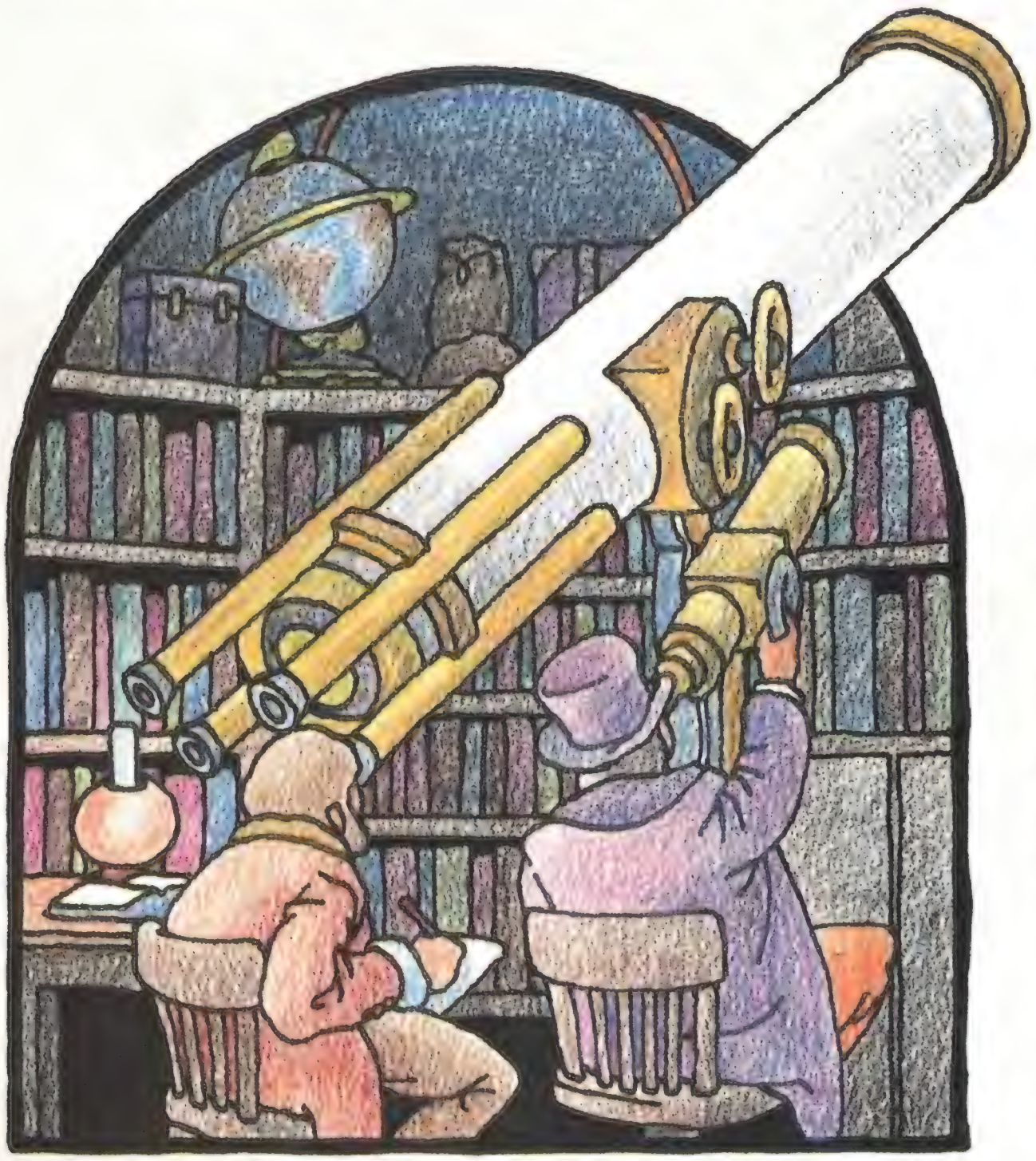
"Show 'I understand' on the Saw-Mill Flat."

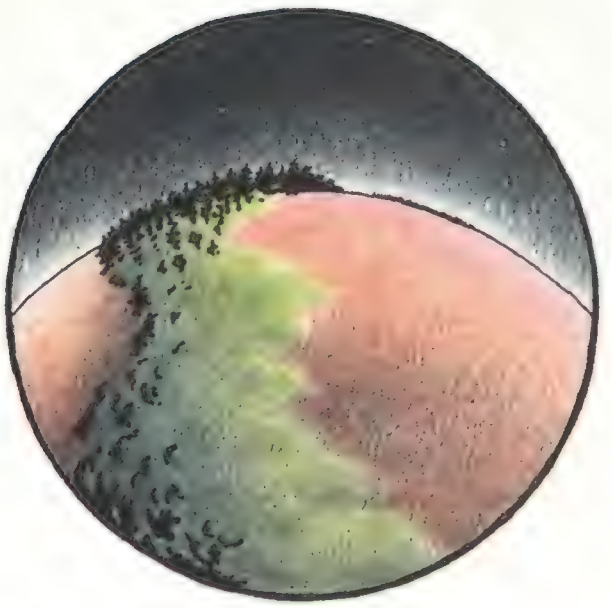
"Show 'I understand' on the Saw-Mill Flat."

"Show 'I understand' on the Saw-Mill Flat."

It was clear that Orcutt had known that the edge of his little world would be most easy of observation, and that he had guessed that the moments of obscuration and of emersion were the moments when observers would be most careful. After this signal they broke up again, and I could not follow them. With daylight I sent off a despatch to Haliburton, and, grateful and happy in comparison, sank into the first sleep, not haunted by horrid dreams, which I had known for years.

Haliburton knew that George Orcutt had taken with him a good Dolland's refractor, which he had bought in London, of a two-inch glass. He knew that this would give Orcutt a very considerable power . . . . Orcutt had chosen well in selecting the "Saw-Mill Flat," a large meadow, easily distinguished by the peculiar shape of the





mill-pond which we had made. Eager though Haliburton was to join me, he loyally took moneys, caught the first train to Skowhegan, and, travelling thence, in thirty-six hours more was again descending Spoonwood Hill . . . . The snow lay white upon the Flat. With Rob. Shea's help, he rapidly unrolled a piece of black cambric twenty yards long, and pinned it to the crust upon the snow; another by its side, and another. Much cambric had he left. They had carried down with them enough for the funerals of two Presidents.

Haliburton showed the symbols for "I understand," but he could not resist also displaying . . — . —, which are the dots and lines to represent O.K., which he says is the shortest message of comfort. And, not having exhausted the space on the Flat, he and Robert, before night closed in, made a gigantic O.K., fifteen yards from top to bottom, and in marks that were fifteen feet through.

I had telegraphed my great news to Haliburton on Monday night. Tuesday night he was at Skowhegan . . . . Friday he and Rob. stretched their cambric. Meanwhile, every day I slept. Every night I was glued to the eye-piece. Fifteen minutes before the eclipse every night this weird dance of leaps two hundred feet high, followed by hops of twenty feet high, mingled always in the steady order I have described, spelt out the ghastly message:

"Show 'I understand' on the Saw-Mill Flat."

And every morning, as the eclipse ended, I saw the column creep along to the horizon, and again, as the duty of opening day, spell out the same:

"Show 'I understand' on the Saw-Mill Flat."

They had done this twice in every twenty-four hours for nearly two years. For three nights steadily, I read these signals twice each night; only these, and nothing more.

But Friday night all was changed. After "Attention," that dreadful "Show" did not come, but this cheerful signal:

"Hurrah. All well. Air, food, and friends! what more can man require? Hurrah."

How like George! How like Ben Brannan! How like George's wife! How like them all! And they were all well! Yet poor *I* could not answer. Nay, I could only guess what Haliburton had done. But I have never, I believe, been so grateful since I was born!

After a pause, the united line of leapers resumed their jumps and hops. Long and short spelled out:

"Your O.K. is twice as large as it need be."

Of the meaning of this, lonely *I* had, of course, no idea.

"I have a power of seven hundred," continued George. How did he get that? He has never told us . . . .

In the record-book of my observations these despatches are entered as 12 and 13. Of course it was impossible for me to reply. All I could do was to telegraph these lines in the morning to Skowhegan, sending them to the care of the Moores, that they might forward them. But the next night showed that this had not been necessary.

Friday night George and the others went on for a quarter of an hour. Then they would rest, saying, "two," "three," or whatever their next signal time would be. Before morning I had these despatches:

14. "Write to all hands that we are doing well. Langdon's baby is named Io, and Leonard's is named Phebe."

How queer that was! What a coincidence! And they had some humor there.

15 was: "Our atmosphere stuck to us. It weighs three tenths of an inch—our weight."

16. "Our rain-fall is regular as the clock. We have made a cistern of Kilpatrick."

This meant the spherical chamber of that name.

17. "Write to Darwin that he is all right. We began with lichens and have come as far as palms and hemlocks."

These were the first night's messages. I had scarcely covered the eye-glasses, and adjusted the equatorial for the day, when the bell announced the carriage in which Polly and the children came from the station . . . . I had the joy of showing her the good news. This night's work seemed to fill our cup. For all the day before, when I was awake, I had been haunted by the fear of famine for them. True, I knew that they had stored away in chambers H, I, and J the pork and flour which we had sent up for the workmen through the summer, and the corn and oats for the horses. But this could not last forever.

Now, however, that it proved that in a tropical climate they were forming their own soil, developing their own palms, and eventually even their breadfruit and bananas, planting their own oats and maize, and developing rice, wheat, and all other cereals, harvesting these six, eight, or ten times—for aught I could see—in one of our years—why then, there was no danger of famine for them. If, as I thought, they carried up with them heavy drifts of ice and snow in the two chambers which were not covered in when they started, why, they had waters in their firmament quite sufficient for all purposes of thirst and of ablution. And what I had seen of their exercise showed that they were in strength sufficient for the development of their little world.

Polly had the messages by heart before an hour was over, and the little girls, of course, knew them sooner than she.

Haliburton, meanwhile, had brought out the Shubael [telescope], and by night of Friday was in readiness to see what he could see. Shubael of course gave him no such luxury of detail as did my fifteen-inch equatorial. But still he had no difficulty in making out groves of hemlock, and the circular openings. And although he could not make out my thirty-seven flies, still when 10.15 came, he saw distinctly the black square crossing from hole Mary to the edge, and begin its Dervish dances . . . . So was it that, at the same moment with me, Haliburton also was spelling out Orcutt & Co.'s joyous "Hurrah" . . . .

He was of course informed long before the Moores' messenger came, that, in Orcutt's judgement, twenty feet of length were sufficient for his signals. Orcutt's atmosphere, of course, must be exquisitely clear.

So, on Saturday, Rob. and Haliburton pulled up all their cambric and arranged it on the Flat again, in letters of twenty feet, in this legend:

RAH. AL WEL.

Haliburton said he could not waste flat or cambric on spelling.

The week we lived a life with cancer.

You know someone who's had cancer. An aunt, a cousin, a father or a close friend. Or maybe a wife and mother who "wanted to go to sleep and wake up and pretend it was just a dream."

But it wasn't a dream for Helen Bartlett. A person Newsweek walked beside during her harrowing medical and psychological odyssey. A person who shared her innermost thoughts and feelings with us.

And, because you experienced Helen's experiences as they happened, you found out what it means to be a cancer victim and live with the imminent threat of dying.

Helen Bartlett didn't make it. But in her 18-month battle, this courageous woman showed all of us what it means to live with cancer.

Finding out what it means, that's what Newsweek is all about and what our in-depth stories have always been about.

In our story on Hiroshima

we told you what it means, after forty years, to live with the bomb still echoing in your mind.

In our special story on homosexuality, we showed you what a desperately lonely and tortured experience it still is to grow up gay in America.

And, in our National Magazine Award-winning report on Vietnam, we told you what it meant for 65 boys, in a company called Charlie, to come home to a silent, indifferent America.

Newsweek constantly lives with people whose lives have meaning to you. Reporting one-on-one about real human beings.

It's one of the reasons we've won more awards for excellence than any other newsweekly.

We speak in a human voice.

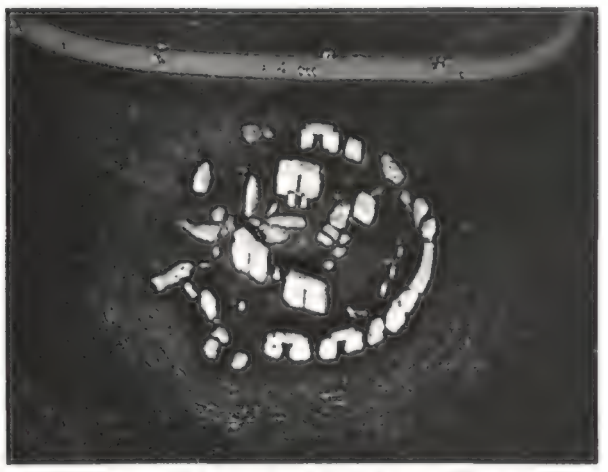
Newsweek

Why it happened. What it means.

Markings: Aerial Views of Sacred Landscapes. *Photographs by Marilyn Bridges; preface by Haven O'More; essays by Maria Reiche, Charles Gallenkamp, Lucy Lippard, and Keith Critchlow. Aperture, 1986. 104 pp., $29.95 (hardbound).*

Marilyn Bridges' photographs capture both the physical details and the spiritual presence of the sacred sites of four distinct cultures. They offer gods'-eye views of the mysterious Nazca lines in Peru, Mayan ruins in Central America, North American Indian artifacts and landscapes, and chalk drawings and stone and earth monuments of Britain and Brittany, France. The images are impressive and evocative in equal measure.

Sadly, the brief essays that precede each group of photographs cannot be so readily enjoyed. Most are written in a dense, scholarly style, and some presuppose familiarity with Bridges' subjects.



From the air, Marilyn Bridges glimpsed the essence of England's sacred sites.

The text is worth skimming, but fortunately, the book can be savored on the basis of the photographs alone.

—Katie Janssen, Associate Editor

"Air Force Spoken Here": General Ira Eaker and the Command of the Air. *By James Parton. Adler & Adler, 1986. 557 pp., $24.95 (hardbound).*

Laconic, articulate Ira Eaker, an architect of American air power and of the Allied victory in World War II, has long deserved a biography. *"Air Force Spoken Here"* is a major step in that direction. Author James Parton, founder of the American Heritage Publishing Company, was General Eaker's aide during World War II and has maintained contact ever since. This well-written book should be read by those who want to understand the history of air power.

Parton outlines Eaker's entire life, from his dirt-poor beginnings in Texas to his many years as a businessman and military affairs commentator. In addition to describing Eaker's brilliant command and diplomatic services during World War II, Parton details Eaker's many exploits as an aviator. This is essential to creating a three-dimensional portrait because Eaker loves the air the way the Wright brothers and Charles Lindbergh did; Eaker's records and accomplishments in aviation would be impressive if they had been achieved by a whole squadron of men.

Three-quarters of Parton's book deals with just four of Eaker's 90 years, the period he served in World War II, and this distribution of attention is appropriate. Between 1942 and 1944 Eaker was commander of the Eighth Air Force, and from January 1944 until the closing months of World War II he was commander of the Mediterranean Allied Air Forces. In the former position, Eaker, starting with literally nothing, built the mightiest destructive force in the history of warfare. He was responsible for negotiating with the British the proper role for American air power, building a vast network of air bases, establishing the logistical system to support the 4,000 airplanes and 185,000 men and women to be sent to England, training crews to fly against Hitler's highly proficient Luftwaffe, and commanding and implementing a strategic bombing effort

that had never really been tested.

Eaker was plagued by late delivery of airplanes and crews (constantly three months or more behind schedule) and ugly weather that hampered his crucial flying training program and the daylight bombing of Germany.

In addition to exceptionally difficult conditions in England, Eaker had to endure incessant hectoring by his long-time friend and mentor General H.H. (Hap) Arnold, commander of the Army Air Forces.

Keenly aware that major success during the war would lead to the creation of an independent air force—his lifelong dream—Arnold hungered for results. The United States was spending huge sums on air power because it believed that strategic bombing could be decisive in producing victory, and Arnold wanted to prove the idea's merit.

But he sent both airplanes and crews too slowly, and, just as significantly, he sent bomber crews that weren't trained to fly and bomb in the huge formations—hundreds of aircraft—necessary for effective bombing. Training crews to fly in tight defensive formations through German anti-aircraft artillery bursts and fighter fire took a major effort that Arnold didn't fully appreciate. Eaker stood up to the harassment and refused to send inadequately trained crews into combat. He was also unwilling to risk losing greater numbers of crews and airplanes than he was receiving. Parton illuminates the grimly candid correspondence between Arnold and his key subordinate. Both men were professional writers, and their letters are models of terse bitterness.

Perhaps Eaker's major contribution to victory was convincing Winston Churchill in early 1943 of the efficacy of the United States' strategic bombing practices. High casualties had forced the British to give up daylight bombing in early 1941 and confine their effort to nighttime area bombing. Eaker, however, adhered to the Army Air Forces' daylight precision bombing doctrine. By late 1942 this policy had not proven itself: Eaker did not have enough personnel and hardware to make it work, and the right targets had not been struck. Churchill was so disillusioned by U.S. ineffectiveness that he came to the Casablanca Conference intending to convince Franklin Roosevelt that the Eighth Air Force should adopt the British technique. Eaker dissuaded Churchill.

Had he not done so, the consequences for the West might have been grave. The Overlord invasion depended on first winning air supremacy over western Europe, which would have been impossible without the U.S. daylight effort. Almost as important, the strategic strikes on key targets, particularly the "oil siege," all but shut down the German war effort while U.S. and British forces raced across Europe. If the West had not exerted this pressure in June 1944, it's impossible to say where the Soviets might have stopped.

Parton also relates, in much less detail, Eaker's 15-month service in Italy as commander of the Mediterranean Allied Air Forces. Here the general commanded even larger forces than those in England, but there is no question that Eaker will be remembered for his command of the Eighth Air Force in its most difficult days.

"Air Force Spoken Here" is an important addition to the bookcases of those interested in aviation, but it is not without faults. Parton, perhaps because of his long friendship with Eaker and his open adulation of the man, got much too close to his subject. The author, furthermore, relies more than prudence permits on oral history, with many of his interviews conducted decades after the events. Most serious of all, Parton's accounts of nearly all controversial subjects are told solely from Eaker's point of view. The book, therefore, fails as historical biography. It has so many virtues, however, and is so well written, that it deserves to be widely read.

—Alan L. Gropman is a principal analyst for SYSCON Corp. The author of several books, he has lectured frequently on aviation at the Smithsonian.

Voyager at Uranus. *A slide set with background material and captions by Sherwood Harrington. Produced and distributed by the Astronomical Society of the Pacific, 1986. 20-pp. booklet and 15 slides, $14.95. Available from ASP, Uranus Slides Dept., 1290 24th Ave., San Francisco, CA 94122.*

It's common enough to take a trip and send some mundane picture postcards back home. The *Voyager 2* spacecraft behaved a little differently: it went all the way to Uranus and sent back some unique images. Taken almost two billion miles from Earth, they revealed previously unseen details of the mysterious seventh planet's system. This sample of *Voyager 2*'s camerawork should prove fascinating for armchair astronomers and anyone whose interest in space extends beyond *Star Wars*.

Ironically, Uranus turned out to be the least photogenic element in its own system, with a thin blue atmosphere discreetly veiling the planet's surface. Only a computer-enhanced image in the set shows it as anything more than a featureless blue orb. Fortunately, Uranus plays the role of a salon host with a house full of stimulating guests, and its rings and moons gave *Voyager 2*'s cameras some good photo opportunities.

The rings proved puzzling: much thinner than expected, they are made of coal black material that reflects little light. Photographing them required long exposure times, so they appear a bit grainy. The ring images look like abstract paintings, or supermarket product codes seen in a funhouse mirror.

The moons displayed a variety of strange sights. Satellite 1985U1 (a more felicitous name hasn't been chosen yet) is the least striking. One of the 10 small satellites discovered by the Voyager, it looks like a small blob of light. Much more revealing and unusual is the small moon Miranda. One slide shows a cliff that towers up to nearly 10 miles—15 times the depth of our Grand Canyon. (Solar system geography tends to trivialize our own planet's features.) Odd patches of grooved sections dot the moon's surface among more familiar-looking cratered areas. It's a cold, desolate, totally alien landscape. Ariel, Titania, Oberon, and Umbriel look equally forbidding, though *Voyager 2* did not pass as close to these moons, so their photographs are not as detailed as Miranda's.

Sherwood Harrington's notes provide an interesting and readable commentary on the slides, punctuated by a number of those colorful similes so dear to scientists (encountering the Uranian system was like "riding on a rifle bullet through the hole in a phonograph record, trying desperately to see details in the record's outer grooves").

An invaluable guide to the slides, the commentary also illuminates the technical achievement behind them: it reveals, for example, that the spacecraft sent its photos to Earth with a 22-watt radio transmitter.

—Tom Huntington, Associate Editor

Ride Through the Solar System. *Story and songs by Michael Stein and Bryan Smith; narration by Fred Newman. Cassette tape, Caedmon, 1987. 34 minutes 31 seconds, $8.95.*

There are some things a person shouldn't do before dropping off to sleep. One of them, apparently, is listening to Jimmy Belt and the Asteroids on the radio. In this cassette for children, little Amanda does just that, and when she and her brother Jake wake up, they find themselves in the right bunk—but the wrong bedroom.

From atop Comet Halley the two begin a musical odyssey around the solar system. Under the kindly and informative guidance of Mr. Halley, Amanda and Jake ride by the planets to the accompaniment of songs about Mercury, Jupiter, and Venus and other celestial topics.

The musical styles are so varied that they are best described by comparison: "Comet Tale Rock" sounds like a cross between Jerry Lee Lewis and Chuck Berry, "I'm Flying" evokes Linda Ronstadt, and throughout there's a hefty dose of Broadway. It's good music, well written, played, and sung. Creative credit goes to Michael Stein (Peter on the album *Jesus Christ Superstar;* he also co-wrote and performed on a similar Caedmon cassette, *Dinosaur Rock*) and Bryan Smith (a former member of the Star Spangled Washboard Band, now with Country Current). Folk aficionados will recognize the instrument and backup vocal contributions of Pete Kennedy and Kathy Fink.

Listeners will like *Ride Through the Solar System* more for the quality of its music than for the corny story—although, to narrator Fred Newman's credit, ET himself couldn't have done much more with the script.

With subjects such as Comet Halley's origins in Oort's Cloud and the nature of Jupiter's moons, the cassette certainly has educational value. Aside from that, however, is its role in simply introducing children to the concept of space in an entertaining way. *Ride Through the Solar System* would be a good investment for parents, schools, camps—and smart babysitters.

—Philip Hayward, Managing Editor

Touch the Sky. *CCR Video Corp., 1986. One-hour videotape, $39.95. Available from Twin Tower Enterprises, 12345 Ventura Blvd., Studio City, CA 91604.*

As if the Navy hasn't had enough publicity from *Top Gun* and a slew of follow-up evening news segments, CCR Video Corporation has let fly with yet another tape of the Blue Angels.

This version stars Christopher Reeve, best known as Hollywood's most recent Superman, who twice flies with the team in the two-seat version of the McDonnell Douglas A-4 Skyhawk II. Reeve seems nervous as he climbs into the back seat, but this is a facade, perhaps intended to heighten the Blue Angels' own superman image—Reeve has been flying civil aircraft for years, and it's a safe bet he was psyched for this flight. Indeed, at one point Reeve even takes the controls, and seems to do quite well.

The tape starts with a brief history of the team, which has been flying airshows since 1946. The Skyhawks, which the Blue Angels flew for 13 years, were traded in for McDonnell Douglas F/A-18s last year. Though the Hornet is faster and more state-of-the-art, many airshow fans will miss the Skyhawk, with its shape, speed, and turn radius so well suited to demonstration flying.

Most of *Touch the Sky* was filmed at a single airshow. The tape contains exciting footage from a camera mounted on the underside of the lead aircraft. In this showcase of formation aerobatics, the movements of the six aircraft are so precise that in a roll, it seems as if they are frozen in the sky while the horizon rotates about them. There are not nearly enough of these exhilarating shots, however. During Reeve's flights, there are only a few seconds of up-close-and-personal footage from the back seat, with the rest filmed from the runway or from a second aircraft.

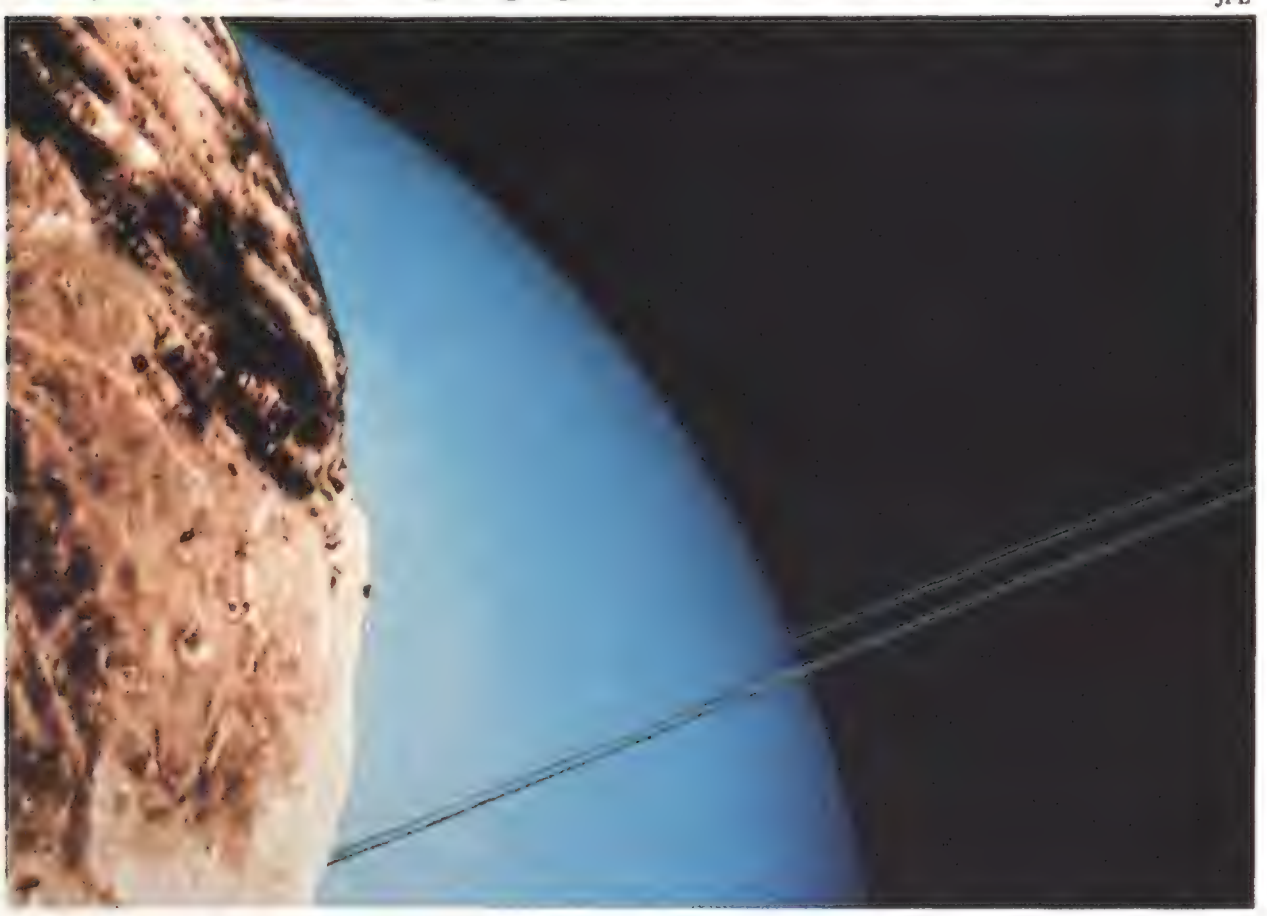
There are really only two vantage points from which an airshow can be fully appreciated: in the aircraft or right at show center, holding your ears. Admittedly, it is difficult to capture the essence of such a performance on film. But this video could have done better.

Though the film is advertised as a Blue Angels "spectacular," it also contains two long segments on vintage military aircraft. Perhaps, as with Reeve's feigned reluctance to fly, this was an attempt to boost the viewer's appreciation of the Skyhawk's performance. However, a few minutes' footage of a T-6 Texan and a Stearman would have been more than sufficient to drive home the point.

The music is the coup de grâce. The tape ends with a piece called "Sky Stallion," the chorus of which exhorts viewers to "Ride your sky stallions, ride 'em fast, ride 'em high." It's enough to make even Reeve think twice about climbing aboard.

—Patricia Trenner, Associate Editor

A composite of Voyager 2*'s images highlights the Uranian moon Miranda.* JPL



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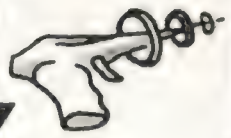
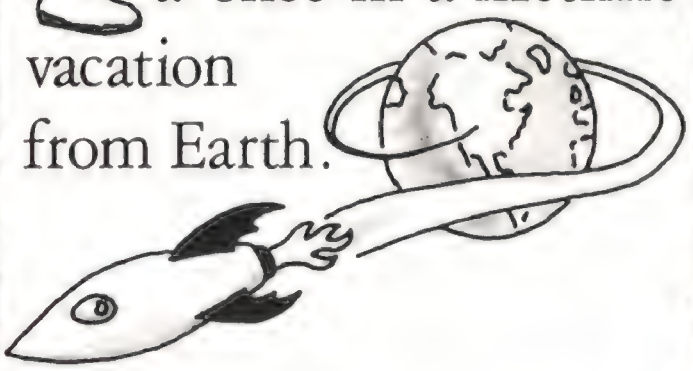


your dragon hunting blade, your alien detector, your pet robot and your galoshes and take a once-in-a-lifetime vacation from Earth.



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Credits & Further Reading

The Rise and Fall of Floyd Bennett Field. Marianne Cannava Scarino is a Brooklyn-based freelance writer whose articles have appeared in a variety of publications. She lives within bicycling distance of Floyd Bennett Field.

Further information: *A 1001 Questions Answered About Aviation History,* C.H. Hildreth and Bernard C. Nalty (Dodd, Mead, and Company, New York, 1969).

Grounded. Katie Janssen is an associate editor at *Air & Space/Smithsonian.*

Further information: "Will Space Telescope Be Ready?," J. Kelly Beatty, *Sky and Telescope,* February 1987.

"The Space Telescope," John N. Bahcall and Lyman Spitzer Jr., *Scientific American* , vol. 247, no. 1, July 1982.

Role Model. J.E. Ferrell is a science and technology writer for the *San Francisco Examiner.* Unlike Christine Fox, she has a private pilot's license. She is also a skydiver.

Further information: *Power at Sea: A Portrait of U.S. Naval Aviation,* produced by International Defense Images (Alexandria, VA, 1986).

The Modern U.S. War Machine: An Encyclopedia of American Military Equipment and Strategy, edited by Ray Bonds (Salamandar, New York, 1987).

Space Station: The Clock Is Ticking. John Logsdon is the director of the graduate program in science, technology, and public policy at George Washington University. He is the author of *The Decision to Go to the Moon.*

Further information: *The Space Station: An Idea Whose Time Has Come,* edited by Theodore Simpson (Institute of Electrical and Electronics Engineers Press, New York, 1985).

Rhapsody in Glue. Daniel Pinkwater is the author of more than 50 books. He built his last model airplane in 1955.

Further information: *The World of Model Aircraft,* Guy R. Williams (G.P. Putnam's Sons, New York, 1973).

Another Opening, Another Show. Patricia Trenner is an associate editor at *Air & Space/Smithsonian.* As part of her research, she pulled more than six Gs during a demonstration flight in Number Eight.

Further information: *Diamond in the Sky: A Pictorial History of the United States Air Force Thunderbirds,* C.A. Knotts and Pete Moore (Specialty Press, Osceola, WI, 1978).

Down to the Sea with Satellites. Hale Montgomery is a freelance writer and the proprietor of Capstone Communications of Washington, D.C., a telecommunications consulting company.

Further information: *United States Civilian Space Programs, Volume II: Applications Satellites* (U.S Government Printing Office, Washington, D.C., 1983, stock no. 052-070-05867-6).

Leapin' Rockets! Tom Huntington is an associate editor at *Air & Space/ Smithsonian.*

Further information: "What It's Like to Fly the New Jet Belt," Robert Courter, *Popular Science,* vol. 195, no. 5, November 1969.

Forward Motion. Eugene F. Mallove is a science writer and astronautical engineer who lives in Bow, New Hampshire.

Further information: *Dragon's Egg,* Robert L. Forward (Ballantine/Del Rey, New York, 1980).

Future Magic, Robert L. Forward (Avon Books, New York, fall 1987).

The Little Yellow Airplane. Jack Doub retired from active duty in the Air Force in 1977 after a 22-year career.

Out of My Class. Mark Evans teaches at the Jefferson Elementary School in St. Louis, Missouri.

Have Art, Will Travel. Jake Page lives in the Virginia countryside, where he expects a fine view of the Eiffel Tower in space, undisturbed by city lights.

"The Satellite Sky" Update

These regular updates to **"The Satellite Sky"** chart will enable readers to keep their charts up to date. Additions can be clipped and affixed to the chart at the appropriate altitude.

Additions grouped by altitude bands

90 to 300 MILES

- Cosmos 1834 4-87 TT
- Kvant 3-87 TT
- Cosmos 1815 1-87 KY
- Soyuz TM-2 2-87 TT
- Cosmos 1824 2-87 PL
- Cosmos 1835 4-87 TT

300 to 630 MILES

- Solar Max 2-80 KSC
- Meteor 2-15 1-87 PL
- Cosmos 1812 1-87 PL
- Cosmos 1814 1-87 PL
- Cosmos 1816 1-87 PL
- Cosmos 1818 2-87 TT
- Cosmos 1821 2-87 PL
- Cosmos 1825 3-87 PL
- Cosmos 1833 3-87 TT
- Astro-C 2-87 KAG
- MOS-1 2-87 TAN

630 to 1250 MILES

- Cosmos 1823 2-87 PL
- Cosmos 1827-32 3-87 PL

21,750 to 22,370 MILES

- Raduga 20 3-87 TT
- GOES 7 2-87 KSC
- Palapa B2P 3-87 KSC

Deletions (630 to 1,250 MILES)

NAVSTAR 3

NAVSTAR 4

NAVSTAR 9 (9-84 Version Only)

Launched but not in orbit

Cosmos 1813 USSR recon	1/15/87 PL	destroyed in orbit
Cosmos 1817 USSR comsat	1/30/87 TT	down after one day, failure
Cosmos 1819 USSR recon	2/7/87 PL	down 2/18/87
Cosmos 1820 USSR unknown	2/14/87 TT	down 3/6/87
Cosmos 1822 USSR recon	2/19/87 PL	down 3/5/87
Progress 28 USSR supply	3/3/87 TT	down 3/28/87
Cosmos 1826 USSR recon	3/11/87 PL	down 3/24/87
Progress 27 USSR supply	1/16/87 TT	down 2/25/87

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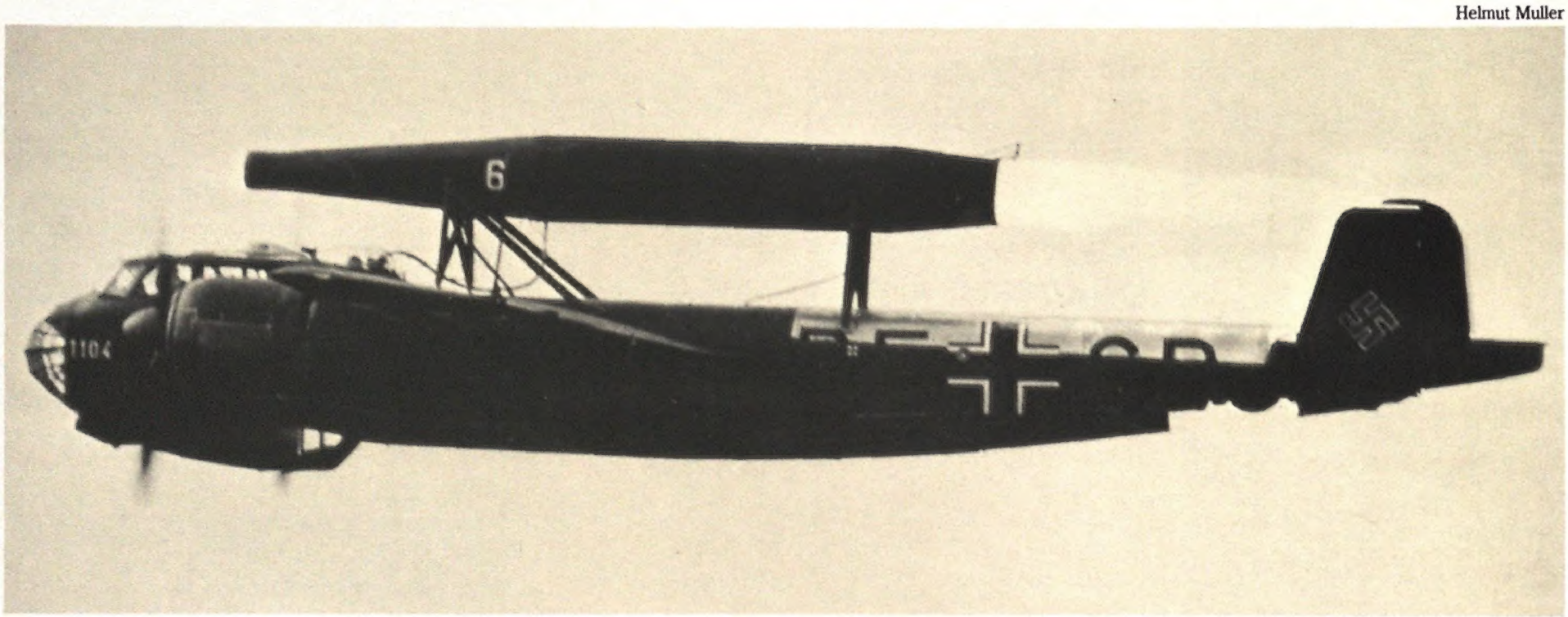

Back to the Future with Eugen Saenger—By mid-century, this Austrian-born physicist and aeronautical researcher had designed an aerospace plane, flight-tested a 20,000-horsepower ramjet that ended up in a supersonic fighter, and done futuristic theoretical work on photon-powered interstellar rocket engines. He dreamed of a strong, independent European role in space exploration. Now Europe is looking back, discovering its future on Saenger's drawing board.

Air Boss—An aircraft carrier's flight deck is a busy place, where airplanes come and go in a complex, high-tech ballet. It's up to the air officer, better known as the air boss, to prevent missteps.

Out-of-this-world Toys—Before there was spaceflight, there were space toys. Now, kids of all ages get a lift out of plastic spaceships, tin robots, and pint-sized spacesuits. Before launching your own collection, though, you might want to check out the costs: prices for Space Age memorabilia can be sky-high.

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